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THIRTY-FOURTH ANNUAL REPORT

OF THE

STATE BOARD OF HEALTH

OF

MASSACHUSETTS.

BOSTON:
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1902–1903.

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GENERAL REPORT.

The following report comprises the general work of the State Board of Health for the year ended Sept. 30, 1902, together with its operations under the food and drug acts for the same period, and under the acts relating to water supply and sewerage during the calendar year 1902.

The first part, paged in Roman numerals, contains a condensed account of the work done under the laws defining the duties of the Board.

The regular work of the Board is performed mainly under the provisions of three separate acts, — an organic act of 1869, establishing the Board; an act of 1882, providing for the inspection of food and drugs; and an act for the protection of the purity of inland waters, of 1886, together with the amendments of these acts, all of which have been embodied in chapter 75 of the Revised Laws of Massachusetts, enacted in 1901.

The second part of this report, paged in Arabic figures, presents the fuller details of the work of the Board under the acts above referred to.

The following members comprised the Board in 1902: —

Henry P. Walcott, *Chairman.*
Hiram F. Mills.
James W. Hull.
Gerard C. Tobey.
Charles H. Porter.
Julian A. Mead.
John W. Bartol.

General Health of the State in 1902.

In the last annual report (for the year 1901) it was stated that the death-rate of the State in that year was the lowest ever recorded. That of 1902, so far as can be estimated from the returns made to the Secretary of State, was still lower, the deaths having been only 47,491 out of an estimated population of 2,937,600, which is equivalent to only 16.17 per 1,000 of the living population. The lowest death-rates in any previous years of the last half of the nineteenth century were 17 per 1,000 in 1867, 17.33 in 1859, and 16.82 in 1901. The highest death-rate in any year of the half-century was that of 1872, which was 22.85, while that of 1849 in the previous half-century was probably still higher. Death-rates in the first half of the last century were probably much greater than they were in later times, in consequence of the greater prevalence of infectious diseases.

The following figures are presented for the ten years ended with 1902 : —

Massachusetts.

YEARS.	Population.*	Deaths.	Death-rates.	YEARS.	Population.*	Deaths.	Death-rates.
1893, ...	2,392,216	49,084	20.52	1898, ...	2,679,049	46,761	17.46
1894, ...	2,445,604	46,791	19.14	1899, ...	2,741,470	47,710	17.40
1895, ...	2,500,183	47,540	19.01	1900, ...	2,805,346	51,156	18.24
1896, ...	2,558,443	49,381	19.30	1901, ...	2,870,710	48,275	16.82
1897, ...	2,618,051	47,419	18.11	1902, ...	2,937,600	47,491	16.17

* Population estimated for intercensal years.

INFECTIOUS DISEASES.

Infectious diseases, their management and control so far as comes within the power and authority of sanitary authority, constitute, under existing laws, the most important part of the duty of boards of health. The death-rate from the principal infectious diseases was generally less than that of 1901. While there was an increase in the number of deaths from small-pox, measles, cholera infantum and whooping-cough, there was also a decrease in those from diphtheria, scarlet fever, typhoid fever, consumption, dysentery, pneumonia and cerebro-spinal meningitis.

The deaths and death-rates from each of the foregoing diseases and from cancer in the past five years are shown in the following table : —

Deaths and Death-rates from Certain Diseases in Massachusetts, 1898-1902.

	1898.		1899.		1900.		1901.		1902.	
	Deaths.	Death-rates per 10,000	Deaths.	Death-rates per 10,000.	Deaths.	Death-rates per 10,000.	Deaths.	Death-rates per 10,000.	Deaths.	Death-rates per 10,000.
Small-pox, ...	–	–	14	.05	3	.011	97	.34	284	.97
Diphtheria and croup, . . .	706	2.64	1,047	3.82	1,475	5.26	1,166	4.06	873	2.97
Scarlet fever, ...	141	.53	235	.86	391	1.39	385	1.34	313	1.07
Typhoid fever, ...	663	2.47	612	2.23	632	2.25	561	1.95	538	1.83
Measles, ...	82	.31	241	.88	330	1.18	173	.60	333	1.13
Cholera infantum, ...	2,320	8.66	1,964	7.16	2,393	8.53	2,705	9.43	3,157	10.75
Consumption, ...	5,288	19.74	5,221	19.05	5,199	18.53	5,033	17.54	4,685	15.95
Dysentery, ...	293	1.09	268	.98	257	.92	223	.78	193	.66
Whooping-cough, ...	337	1.26	338	1.23	337	1.20	210	.73	337	1.15
Pneumonia, ...	4,206	15.70	4,993	18.21	5,282	18.83	4,772	16.62	4,583	15.60
Cancer, ...	1,907	7.12	1,838	6.70	1,998	7.12	2,080	7.25	2,141	7.29
Cerebro-spinal meningitis, . .	259	.97	240	.88	198	.71	177	.62	165	.56

No serious epidemic of a general character proving fatal to large numbers of the population has prevailed throughout the State for several years, or since the epidemic of influenza of 1889–90. The principal epidemic years of the last century were 1849 and 1872, in each of which infectious diseases of a destructive character were unusually prevalent.

In the following table a balance is shown between the principal infectious diseases of 1901 and 1902. By this table it appears that the sum of the deaths from these eleven principal infectious diseases in 1902 was less by 41 than those of 1901 from the same causes. The effect of this gain upon the general population is shown in the following quotation from the report of 1901: —

> The improvement in the death-rate from infectious diseases is of much greater importance than the loss resulting from the increase in the death-rate from such diseases as cancer, and the diseases of the heart, kidneys and brain, when the figures of 1901 are compared with those of any of the early years of the last half-century, because the lives saved are more valuable than the lives lost, those of the former class being chiefly of the young who are just entering upon the useful period of life, while the latter are mostly those of old people who have passed that period.

Deaths from Certain Infectious Diseases in 1901 and 1902.

DISEASES.	1901.	1902.	Increase.	Decrease.
Small-pox,	97	284	187	–
Diphtheria and croup,	1,166	873	–	293
Scarlet fever,	385	313	–	72
Typhoid fever,	561	538	–	23
Measles,	173	333	160	–
Cholera infantum,	2,705	3,157	452	–
Consumption,	5,033	4,685	–	348
Dysentery,	223	193	–	30
Whooping-cough,	210	337	121	–
Pneumonia,	4,772	4,583	–	189
Cerebro-spinal meningitis,	171	165	–	6
	15,502	15,461	920	961

This remarkable change in the incidence of different diseases upon the population has been going on for many years, not only among American populations, but upon those of other countries, as shown in the reports of those countries.

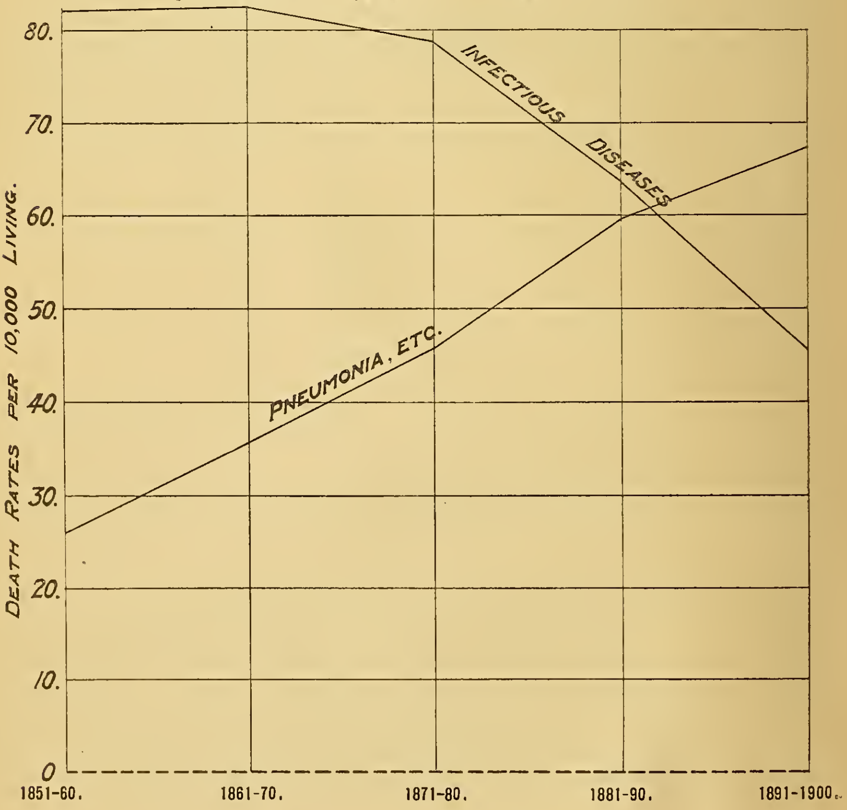
As an illustration of this fact the following table and diagram have been constructed from the data published in the Registration reports of the State for the fifty-year period 1851–1900. The causes of death embraced in columns 1 and 2 are the following: Small-pox, measles, scarlet fever, diphtheria, typhoid fever, dysentery, cholera infantum, consumption, childbirth and whooping-cough. Those embraced in columns 3 and 4 are pneumonia, cancer, kidney diseases, heart diseases and brain diseases.

The added figures for the years 1901 and 1902 confirm the same principle, and show that these progressive changes are still going on.

Deaths and Death-rates from Certain Diseases in Massachusetts by Ten-year Periods, 1851-1900.

PERIODS.	1 Deaths.	2 Death-rates per 10,000.	3 Deaths.	4 Death-rates per 10,000.
1851-60,	94,355	83.2	29,509	26.0
1861-70,	109,845	83.5	46,969	35.7
1871-80,	129,952	78.7	75,740	45.9
1881-90,	121,293	60.7	119,093	59.6
1891-1900,	115,403	45.5	170,716	67.3

DIAGRAM SHOWING COMBINED DEATH RATES FROM CERTAIN INFECTIOUS DISEASES, AND FROM PNEUMONIA, CANCER AND CERTAIN LOCAL CAUSES.



The Death-rate of Cities.

The State of Massachusetts has become so densely settled, so far as relates to its urban population, as to require a better method of computing the death-rates of large cities than that which is usually employed, when it is desirable to compare the death-rates of such cities with each other. In only one of the States of the Union (Rhode Island) is the population more densely settled than that of Massachusetts. The population of the State, now about three millions, is limited to a little more than eight thousand square miles of territory, or about 375 persons per square mile. These, however, are very unequally distributed, the cities, 33 in number, each having over 12,000 inhabitants, containing about three-fourths of the entire population.

The following tables are presented for the purpose of showing the method of comparing the death-rates of different cities with each other, when the conditions as to the relative numbers of persons of different sexes and ages are not the same in each. The crude or recorded death-rate of any city for a given year, as obtained by comparing the existing population with the number of deaths in the year, may be compared with the death-rate of the same city for any other year or series of years, but it cannot be compared with that of another city, for the same year, unless the populations of the two cities have an identical relative distribution of the population by sexes and ages.

For example: the crude death-rates of the older cities and towns of the Atlantic sea-coast cannot properly be compared with those of new western cities, in which the relative number of persons of young and healthy ages is in excess of that in the former cities, while the population at advanced ages is also correspondingly smaller. For this reason the registrar-general of England has devised the method of referring the figures of different communities, cities and towns to some standard population, such as that of the country at large, or, as advised by other experts, to that of some very healthy population, like that of Sweden.

In the following table the population and deaths in the State at large are assumed as a standard, and the death-rates of the cities are compared with this standard. The method is fully explained in the last edition of Newsholme's "Vital Statistics."

The statistics of the year 1900 are here selected for presentation because the census enumeration was taken in that year. The data for sexes and ages, however, were only published for cities having a population of 25,000 or more in each. This includes 20 of the large cities of Massachusetts.

In certain cities the death-rate is unfavorably influenced by the presence of public and private institutions, in which a considerable number of non-resident patients are treated whose deaths should not be credited to the death-rate of those cities. An allowance has therefore been made of 419 deaths of such non-residents in Boston, of 119 in Worcester, of 79 in Taunton, and of 90 in Chelsea, all of which occurred in sixteen public and private institutions during the census year 1900.

For the purposes of this comparison a mean annual mortality of the State by ages and sexes for the three years 1899, 1900 and 1901 was calculated and applied to the population of each city in this group. This mean annual rate for each sex and age is shown in the following table: —

Death-rates by Sexes and Ages. 1899–1901.

AGES.	Males.	Females.	Persons.	AGES.	Males.	Females.	Persons.
0- 5, . .	58.41	48.00	53.21	25-35, . .	7.96	7.31	7.63
5-10, . .	4.74	4.60	4.67	35-45, . .	10.48	9.42	9.95
10-15, . .	2.84	2.88	2.86	45-55, . .	16.26	14.20	15.21
15-20, . .	4.70	4.43	4.56	55-65, . .	30.96	26.51	28.59
20-25, . .	6.71	5.94	6.30	65 +, . .	88.60	82.78	85.35

From this table it appears that the death-rate at each age period between 5 years and 55 years was less than that of the State for all ages (which was 17.48 for the three years). Under 5 years and over 55 the death-rate is much higher than the combined death-rate of the State. If, therefore, the proportion of the total population living at different ages differs much in different cities or communities, then the total death-rates at all ages will also differ, independently of sanitary conditions.

The same rule applies to sex distribution. At all of the age periods, except ages 10–15, the female death-rate is lower than that of the male; hence an excess of females also tends to lower the general death-rate irrespective of sanitary conditions.

Census of 1900.

AGES.	AGE DISTRIBUTION OF POPULATION OF					
	MASSACHUSETTS.		HOLYOKE.		SALEM.	
	Males.	Females.	Males.	Females.	Males.	Females.
0-5 years, ...	505	501	610	618	530	520
5-10 years, ...	457	456	550	556	506	473
10-15 years, ...	407	411	480	498	411	427
15-20 years, ...	411	437	448	525	405	449
20-25 years, ...	461	534	454	627	449	519
25-35 years, ...	921	955	849	972	842	920
35-45 years, ...	704	708	658	643	631	710
45-55 years, ...	470	492	398	411	448	523
55-65 years, ...	292	334	216	244	286	377
65 years and over, ...	224	286	83	140	220	328
Unknown, ...	23	11	12	9	13	13
	4,875	5,125	4,758	5,242	4,741	5,259
	10,000		10,000		10,000	

To illustrate this principle the foregoing table is presented, containing the distribution of the population by sexes and ages in the State at large, and in the two cities, Holyoke and Salem.

In Holyoke the combined population at ages 0–5 and all over 55 constituted 19.1 per cent. of the whole population, while that of Salem at the same ages was 22.6 of the whole. In the case of Holyoke the percentage of the population at these ages was less than that of the State for the same ages, notwithstanding its high birth-rate, but its population at advanced ages is relatively small, as is usually the case in comparatively new cities. In Salem, a much older city, the population under 5, and also that which is over 55, is greater than that of the State at the same ages, thus favoring a higher death-rate in Salem and a lower one in Holyoke than that of the State at large.

The method of correcting the death-rates for sex and age distribution is shown in the following tables : —

Recorded and Corrected Death-rates per 1,000 persons living in Massachusetts Cities of more than 25,000 Inhabitants in 1900.

Cities in the Order of their Corrected Death-rates.	1 Standard Death-rates.	2 Factor for Correction for Sex and Age Distribution.	3 Recorded Death-rates. **1900.**	4 Corrected Death-rates. **1900.**	5 Comparative Mortality Figure.
MASSACHUSETTS,	17.48	1.000	18.23	18.23	1.000
Brockton,	16.27	1.074	13.85	14.87	0.816
Malden,	17.02	1.027	14.53	14.92	0.818
Newton,	17.06	1.024	15.01	15.37	0.843
Haverhill,	17.67	0.989	15.55	15.38	0.844
Somerville,	17.30	1.010	15.67	15.83	0.868
Fitchburg,	17.02	1.027	15.67	16.09	0.883
Chelsea,	17.77	0.984	16.42	16.16	0.886
Lynn,	16.80	1.040	15.91	16.55	0.908
Gloucester,	17.33	1.009	17.00	17.15	0.941
Cambridge,	16.54	1.056	16.54	17.47	0.958
Springfield,	17.31	1.010	18.93	19.12	1.049
Salem,	17.95	0.974	19.86	19.34	1.061
Worcester,	16.56	1.056	18.33	19.36	1.062
Taunton,	16.89	1.035	19.43	20.09	1.102
Lowell,	16.07	1.088	19.48	21.19	1.163
Boston,	16.26	1.075	20.08	21.59	1.184
New Bedford,	17.07	1.024	21.19	21.70	1.190
Lawrence,	16.09	1.086	20.40	22.15	1.215
Fall River,	15.90	1.099	21.53	23.66	1.297
Holyoke,	15.55	1.124	21.96	24.68	1.354

In this table the Standard Death-rate signifies the death-rate at all ages calculated on the hypothesis that the death-rates at each of the ten age periods in each city were the same as in Massachusetts during the three years 1899–1901, the death-rate at all ages in Massachusetts during that time having been 17.48 per 1,000. The Factor for Correction is the figure by which the crude or recorded death-rate should be multiplied in order to correct for variations of sex and age distribution. The Corrected Death-rate is the recorded death-rate multiplied by the Factor for Correction. The Comparative Mortality Figure represents the Corrected Death-rate in each city, compared with the Recorded Death-rate at all ages in Massachusetts in 1900 taken as 1000.

The figures in this column (5) may be read as follows: after making approximate corrections for differences of age and sex distribution, the same number of living persons that gave 1,000 deaths in Massachusetts in 1900 gave 816 in Brockton, 818 in Malden, 1,354 in Holyoke, etc.

The first column in the table is obtained by assuming that the mean mortality in Massachusetts in the three years 1899–1901 prevailed in each city. The age and sex distribution of each of these cities at the census of 1900 being known, the mean mortality in Massachusetts in 1899–1901 is applied to the population thus constituted, and the result is the series of death-rates in column 1. The differences in the death-rates of the cities in this column are therefore caused only by the difference in the age and sex distribution of their inhabitants.

The following example shows the method of obtaining these standard death-rates: —

The population of Holyoke in 1900 was 45,712; the total number of calculated deaths in Holyoke was 711; the standard death-rate was, therefore, $\frac{711 \times 1000}{45712} = 15.55$, as shown in the table, page xiii.

Now the mean annual death-rate of Massachusetts in 1899–1901 was 17.48. This should be the same as the calculated death-rate for Holyoke, which was obtained by applying the mean annual death-rate of Massachusetts at the different age groups to the population of Holyoke at the same ages.

AGES.	MEAN ANNUAL DEATH-RATE IN MASSACHUSETTS, 1899-1901, PER 1,000 LIVING AT EACH GROUP OF AGES.		POPULATION OF HOLYOKE. **1900.**		CALCULATED NUMBER OF DEATHS IN HOLYOKE.	
	Males.	Females.	Males.	Females.	Males.	Females.
Under 5 years, .	58.41	48.00	2,787	2,824	163	135
5-10 years, . .	4.74	4.60	2,514	2,542	12	12
10-15 years, . .	2.84	2.88	2,194	2,276	6	6
15-20 years, . .	4.70	4.43	2,048	2,400	10	11
20-25 years, . .	6.71	5.94	2,075	2,866	14	17
25-35 years, . .	7.96	7.31	3,881	4,445	31	32
35-45 years, . .	10.48	9.42	3,006	2,940	31	28
45-55 years, . .	16.26	14.20	1,818	1,879	30	27
55-65 years, . .	30.96	26.51	985	1,113	30	29
65 years and over,	88.60	82.78	381	642	34	53
Unknown, . .	-	-	55	41	-	-
	-	-	21,744	23,968	361	350
			45,712		711	

But the calculated or standard death-rate for Holyoke is lower, as shown above, which must arise from the fact that the distribution of ages and sexes in the Holyoke population is more favorable than in the State at large. This can be seen by consulting the table on page xii.

The standard death-rate in Holyoke, being lower than that of the State, must be raised in a certain ratio in order to bring it into comparison with that of the State. It must be increased in the proportion of 15.55 to 17.48.

The factor for correction for age and sex distribution, by which the recorded death-rate of Holyoke must be multiplied in order to make it comparable with that of Massachusetts is $\frac{17.48}{15.55} = 1124$. We have employed a triennial correction figure as a constant, having the census year 1900 as the middle year of the three. Any error which may be due to the use of a triennial correction figure instead of a special correction figure for a single year is so small that it may practically be disregarded. By multiplying the recorded death-rates in column 3 by the factors for correction, the corrected death-rates in column 4 are obtained. These are the death-rates which would have been recorded in each town had its population been identical, so far as age and sex distribution are concerned, with the population of Massachusetts.

Small-pox.

The beginning of the epidemic of small-pox, which has prevailed in Massachusetts from the spring of 1901 until the present time (June, 1902), but which appears to be nearly at an end, was reported upon in the last annual report of the Board. This epidemic reached its height in January, 1902, in which month 347 cases were reported, with 35 deaths. From that time the monthly roll of cases gradually diminished until midsummer, after which there was again an increase until the close of the year, but the number of cases reported monthly in the past winter was less than half as great as that of the preceding winter.

Comparing the epidemic of 1902 with that of former years, the number of cases and also the number of deaths were very much in excess of those of any year since the epidemic of 1872–73, but by no means as great as they were in that epidemic.

Relatively, the mortality from small-pox in 1902 was at the rate of a little more than .9 per 10,000 (93 per million inhabitants), while that of 1872 was 6.7, or about seven times as great, and that of 1873 was 4.3.

In the twenty-five years (1851–75) the death-rate from small-pox exceeded that of 1902 13 times, viz., in 1851, '54, '55, '56, '59, '60, '64, '65, '66, '67, '71, '72 and '73; but in no single year of the last quarter of the nineteenth century did it rise higher than .25 per 10,000, or but little more than a quarter of its rate in 1902.

The whole number of reported cases during the year 1902 was 2,305, of whom 1,359 were males and 942 were females, and the sex of 4 was not stated. Out of this number, 274 died, — 173 males and 101 females. The general fatality was therefore 11.9 per cent.

The cases and deaths were distributed throughout the year as follows: —

Months.	Cases.	Deaths.	Months.	Cases.	Deaths.
January,	347	35	August,	79	14
February,	282	28	September,	88	12
March,	281	20	October,	110	16
April,	241	26	November,	160	23
May,	249	34	December,	161	20
June,	169	25			
July,	138	21		2,305	274

Distribution of the Disease. — The cases reported to the Board were widely distributed throughout the State. The whole number of cities and towns from which cases were reported to the Board was 122, every city out of the 33 cities in the State reporting cases, varying in number from 1 to 1,024. Boston and the metropolitan district, however, suffered most severely from the epidemic. Out of the 2,305 cases which were reported, 1,024 were reported from Boston and 1,522 from the metropolitan district, or 66 per cent. of the whole. This district contained, by the census of 1900, 40 per cent. of the population of the State.

The cities in the metropolitan district outside of Boston which suffered most severely were Cambridge, Somerville, Everett and Malden, with 174, 64, 52 and 36 cases, respectively. Out of the 30 cities and towns within 10 miles of Boston, there were only 5, Belmont, Dedham, Lexington, Needham and Winthrop, in which there were not one or more cases reported during the year.

Outside of the metropolitan district, the number of cases showed very little relation to the numbers of the population, several small manufacturing villages suffering severely. The cities and towns reporting the largest number of cases were the following: Hardwick (Gilbertville), 60; Lowell, 53; Northbridge, 43; Southbridge, 41; Dudley, 38; Salem, 36; Webster, 25; Holyoke, 20; Gardner, 20; New Bedford, 19; Lawrence, 19; Sturbridge, 18; Wayland, 18; Taunton, 17; Fall River, 14; Springfield, 12; and Marlborough, 12.

In some of the small manufacturing towns there had been gross neglect of the laws relating to the vaccination of employees of manufacturing corporations. In one or more instances, notably at Gilbertville, very many cases were not reported, since the epidemic at that place had continued from November, 1901, until March, before any cases were reported to the Board, the cases being either unrecognized or not reported.

It appears probable that the 2,305 cases officially reported to the Board in 1902 do not represent the sum total of all the cases which occurred in the State, since, after careful inquiry, there were a few towns in which cases were, as in the town of Hardwick, either unrecognized or concealed at the time of their occurrence. The whole number of such cases did not probably exceed 200 in all. The law requiring reports to be made in all instances, under penalty of forfeiture of claim upon the State for expenses of State cases, has undoubtedly exercised a salutary effect in making the reports of cases fairly complete.

The comparative immunity of the paper mill towns and villages in this epidemic is notable, when compared with the facts reported in earlier epidemics, especially in that of 1872–73, this fact being undoubtedly due to the greater care which such towns have taken to secure the vaccination of their inhabitants who were specially exposed to small-pox in consequence of the use of rags in the manufacture of paper.

Occupations. — The occupations of persons attacked are not stated with sufficient detail to enable us to present exact figures. It appears, however, from the returns received, that women engaged in housework, laborers, teamsters, mill operatives and shoemakers were attacked in largest numbers.

Persons engaged in certain occupations, however, are specially exposed to attack during epidemics of small-pox, and these are nurses, physicians, laundry operatives, the employees of paper mills and those of the transportation companies. During the year 1902, 11 nurses, 6 physicians, 4 laundry operatives and 6 railway employees were reported as having small-pox.

Of the nurses, 4 had been vaccinated and 7 were unvaccinated. Of the physicians, 1 only was unvaccinated. The seven unvaccinated nurses probably constituted all of the unvaccinated nurses employed during the epidemic in attending patients ill with small-pox.

The comparative immunity of railway employees, when the large number employed is considered, was undoubtedly due to the care taken by the large corporations in securing the vaccination of their operatives during the early part of the epidemic.

Summary of Several Years. — The following table presents the numbers of cases and of deaths from small-pox in the period of twenty years from 1883 to 1902 inclusive: —

YEARS.	Cases.	Deaths.	YEARS.	Cases.	Deaths.
1883, ...	21	5	1895, ...	1	–
1884, ...	9	3	1896, ...	5	–
1885, ...	32	19	1897, ...	18	4
1886, ...	2	–	1898, ...	12	–
1887, ...	13	3	1899, ...	105	14
1888, ...	32	9	1900, ...	104	3
1889, ...	15	6	1901, ...	778	101
1890, ...	6	1	1902, ...	2,305	274
1891, ...	5	3			
1892, ...	19	2	Total, ...	3,712	489
1893, ...	45	9			
1894, ...	185	33	Fatality, 13.2 per cent.		

Sex. — The record of the distribution of the sexes begins with 1885, and shows that the number of males attacked was 2,109 and that of females 1,513, or in the ratio of 139 males to 100 females.

In a few instances in the earlier years of the period the sex was not stated.

Fatality. — The whole number of cases reported was 3,712 and the deaths 489, or 13.2 per cent. The epidemic of the past two years was unusually mild in character. The fatality in the year 1902, when the greater portion of the cases occurred, was only 11.9 per cent.

Condition as to Vaccination. — Of 3,634 reported cases which occurred since and including 1888, 1,522 were vaccinated, and of these there were 133 deaths; 2,046 were unvaccinated, and of these there were 302 deaths. In 66 cases the facts in regard to vaccination were not stated, and of these there were 10 deaths.

Ages. — The information derived from the records of cases of small-pox, when considered with reference to the ages of the persons attacked, together with the number and ages of these which terminated fatally, is of the highest importance in its bearing upon the efficiency of vaccination as a life-saving measure.

The following table presents the age incidence of this disease, both upon the morbidity and the mortality of small-pox in Massachusetts in the period 1888–1902, the vaccinated, the unvaccinated and those among whom the facts as to vaccination were unknown being separately classified. These facts are obtained from the official returns of local boards of health to the State Board of Health.

Small-pox in Massachusetts, by Ages, and with reference to Vaccination, 1888-1902.

AGES.	VACCINATED.		UNVACCINATED.		UNKNOWN.		TOTAL.	
	Cases.	Deaths.	Cases.	Deaths.	Cases.	Deaths.	Cases.	Deaths.
Under 1 year, ...	3	–	147	44	2	–	152	44
1 to 5 years, ...	28	–	431	53	4	1	463	54
5 to 10 years, ...	28	–	225	8	6	–	259	8
10 to 15 years, ...	41	–	92	4	2	–	135	4
15 to 20 years, ...	83	3	208	17	6	2	297	22
20 to 30 years, ...	407	27	504	76	20	5	931	108
30 to 40 years, ...	452	41	251	48	6	1	709	90
40 to 50 years, ...	285	28	119	32	7	–	411	60
Over 50 years, ...	185	34	60	16	3	1	248	51
Ages unknown, ...	10	–	9	4	10	–	29	4
	1,522	133	2,046	302	66	10	3,634	445

From the foregoing table the following significant facts may be noted: —

Only 3 vaccinated children under one year of age were attacked with small-pox, and these all survived; while there were 147 attacks of unvaccinated infants under one year old, and of this number 44 died, or 30 per cent.

Among vaccinated persons under fifteen years old there were 100 attacks and no deaths; but among unvaccinated persons of the same ages there were 895 attacks and 109 deaths.

Among vaccinated adults over fifteen years of age there were 1,412 attacks and 133 deaths; and among unvaccinated persons over fifteen years old there were 1,142 attacks and 189 deaths.

It is also worthy of notice that 386 school children, or children of school ages (five to fifteen years), were attacked, and of this number 317, or more than four-fifths, were unvaccinated. There were only 12 deaths out of this number, since this is the period of life when the power to resist fatal attacks of disease is greatest.

Out of the 1,522 who were recorded as having been vaccinated, it was stated in the returns that 1,054, or nearly 70 per cent., had been vaccinated in childhood or infancy only; and nearly every one of the deaths of adults recorded as "vaccinated" occurred among this class.

The foregoing figures illustrate the decided saving of life among persons of early ages, the gross neglect of vaccination of school children, and the neglect of revaccination among adults.

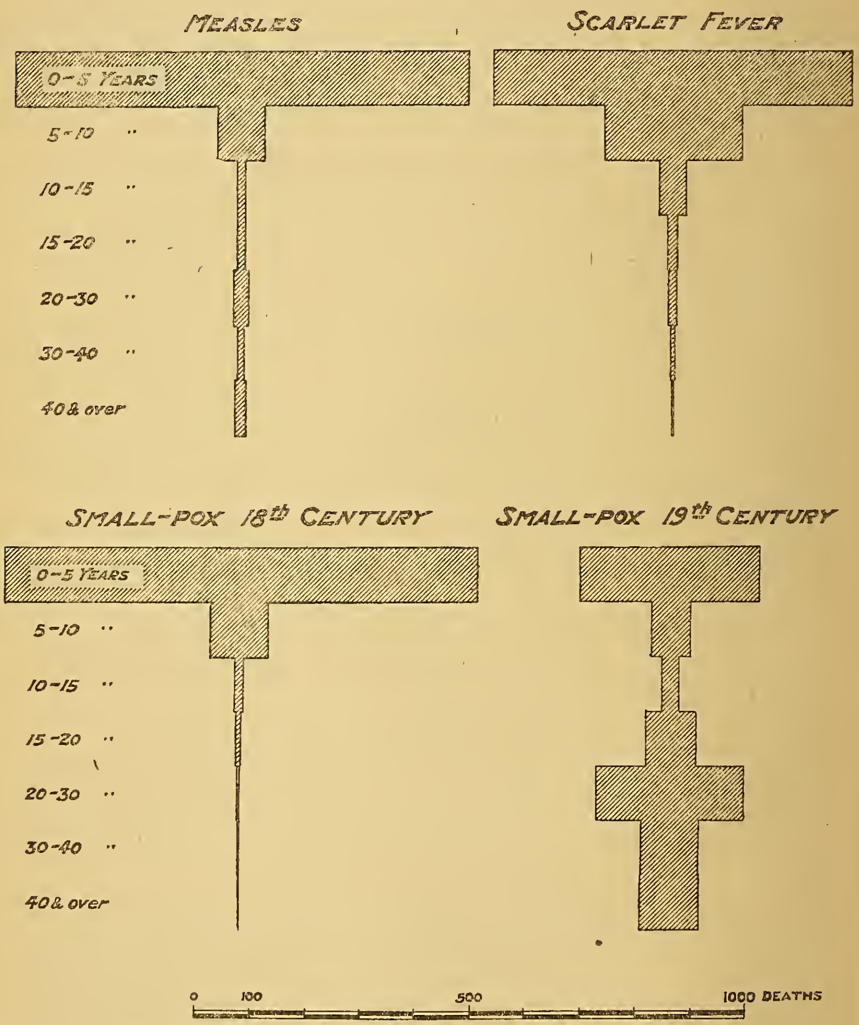
The change in the age incidence of small-pox since the introduction of vaccination is one of the most important proofs of the effect of this practice.

Before the discovery and introduction of vaccination, small-pox was preeminently a disease of children, — quite as much so as either scarlet fever or measles.

The immunity from small-pox secured by the vaccination of infants is not permanent, and vaccination should therefore be repeated at the end of about ten years. (The German law requires revaccination at twelve years of age; and the new law of France requires three vaccinations, one during the first year, another in the eleventh year and a third in the twenty-first year.)

Now, since a very large share of the population is vaccinated in infancy, but many of these persons neglect revaccination, consequently the number of attacks and the deaths resulting from the same are carried forward, and occur in the adult ages of life. The effect of this is shown in the following diagram, in which are shown the numbers of the population who die at certain ages from measles and scarlet fever out of each thousand persons at all ages. Another diagram also shows the distribution of small-pox mortality by ages in the eighteenth century. In the case of measles and scarlet fever nothing has yet been discovered by which immunity may be produced at early ages; but vaccination in the case of

DISTRIBUTION OF 1000 DEATHS FROM CERTAIN CAUSES BY AGES



small-pox has wrought a very decided change in the age distribution of small-pox mortality, as shown by the second diagram.

The figures for making the diagram illustrating the small-pox mortality in the eighteenth century were taken from the very carefully kept records of two English towns, one Scotch town and the city of Geneva in Switzerland.

Those which were employed for the diagrams illustrating measles, scarlet fever and small-pox in the nineteenth century were the experience of the mortality from these causes in Massachusetts in the period of forty years, 1856–95. The whole number of deaths from these causes in the forty years was 46,662.

Consumption.

The change which has been constantly progressing in the death-rate from consumption constitutes one of the marked features of the vital statistics of most civilized countries at the present day. In a recent number of "Public Health," a journal published in London, Dr. Hillier* shows that, if the present rate of decrease in the mortality of this disease is continued with the same uniform rate for several years longer, its extinction may be looked for in England within the next half century.

The same rule applied to Massachusetts would apparently show the extinction of the disease in our population even within a shorter period. For many years the number of deaths from this disease exceeded 5,000 per year in Massachusetts, the greatest number occurring in 1885, when there were 5,955. But not only has the relative number of deaths from this disease rapidly diminished, but the absolute number has also fallen from 5,955 in 1885 to 4,685 in 1902.

The deaths from this cause in 1902 were 4,685, and constituted 15.9 per 10,000 of the living population, as compared with 42.7 in 1853, a period of fifty years.

The following table presents the death-rate from consumption in Massachusetts for the first ten years and the last ten years of the past half-century: —

Death-rates from Consumption in Massachusetts per 10,000 Inhabitants. Two Ten-year Periods.

Years.	Ten Years, 1853-62.	Years.	Ten Years, 1893-1902.
	Death-rates from Consumption.		Death-rates from Consumption.
1853,	42.7	1893,	23.1
1854,	41.8	1894,	22.3
1855,	41.9	1895,	21.9
1856,	40.8	1896,	21.7
1857,	39.5	1897,	20.8
1858,	38.4	1898,	19.7
1859,	38.9	1899,	19.0
1860,	37.0	1900,	18.5
1861,	36.5	1901,	17.5
1862,	34.3	1902,	15.9

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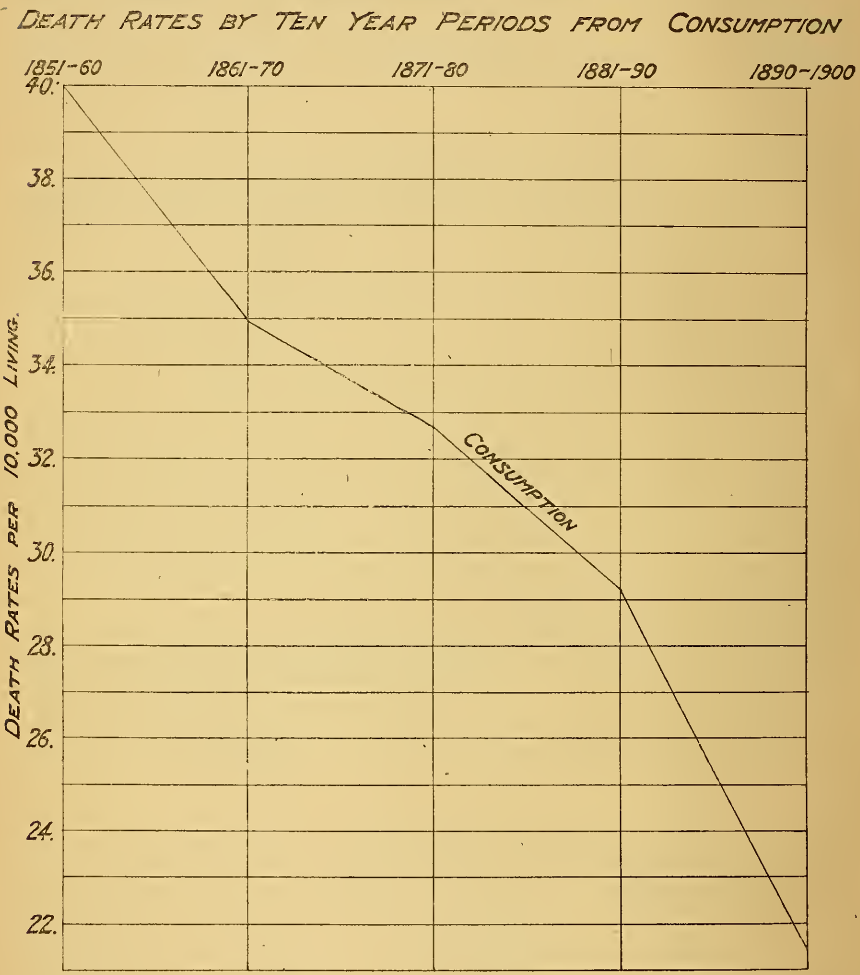
* The Prospect of Extinguishing Tuberculosis, by Alfred Hillier, M.D. Public Health, March, 1903.

In the following diagram the decrease in the death-rate from consumption by ten-year periods in Massachusetts is shown for the half century



1851–1900. The figures for 1901 and 1902 as given below also show the same general direction of progressive fall in the death-rate.

Deaths and Death-rates from Consumption in Massachusetts, 1851–1902.

Periods.	Deaths.	Death-rates per **10,000.**	Periods.	Deaths.	Death-rates per **10,000.**
1851-1860, ...	45,252	39.9	1891-1900, ...	54,374	21.4
1861-1870, ...	45,913	34.9	1901, ...	5,033	17.5
1871-1880, ...	54,039	32.7	1902, ...	4,685	15.9
1881-1890, ...	58,303	29.2			

Typhoid Fever.

Typhoid fever is an infectious disease to which the term "preventable" clearly applies. A high death-rate from this cause in any community usually gives evidence of carelessness or neglect either in the management or control of the local water supply or of the milk supply. Very many of the epidemics of this disease which have occurred in the State in recent years have been traceable to the milk supplies of cities and towns and to careless and unclean methods of handling such supplies.

In the recent reports of the Board, tables have been presented giving the statistics of mortality from this cause in the cities of the State since 1871, showing a fairly uniform decrease since that year. The mean death-rate of the 33 cities in 1901 was shown to have been but little more than one-fourth as great as it was in the five-year period 1871–75.

The following table presents the figures for the two years 1901 and 1902 in each city, by which it appears that the mean death-rate in the 33 cities for the two years 1901–02 was 2.01 per 10,000. The highest death-rates from this cause were 4.5, 3.5 and 3.5, respectively, in Newburyport, New Bedford and North Adams; and the lowest were 0.9, 04 and 0.4, in Cambridge, Woburn and Marlborough.

Deaths and Death-rates from Typhoid Fever in the Cities of Massachusetts, 1901-02.

CITIES.	Deaths from Typhoid Fever, **1901-02.**	Death-rates per **10,000.**	CITIES.	Deaths from Typhoid Fever, **1901-02.**	Death-rates per **10,000.**	CITIES.	Deaths from Typhoid Fever, **1901-02.**	Death-rates per **10,000.**
Newburyport, .	13	4.5	Lawrence, . .	28	2.1	Northampton, .	5	1.3
New Bedford, .	45	3.5	Everett, . .	10	1.9	Beverly, . .	4	1.3
North Adams, .	18	3.5	Melrose, . .	5	1.9	Lynn, . . .	19	1.3
Chelsea, . .	21	3.0	Lowell, . .	35	1.8	Somerville, . .	16	1.2
Waltham, . .	14	2.9	Chicopee, . .	7	1.7	Newton, . .	8	1.1
Pittsfield, . .	12	2.8	Worcester, . .	43	1.7	Medford, . .	4	1.0
Malden, . .	19	2.7	Fitchburg, . .	11	1.7	Cambridge, .	18	0.9
Taunton, . .	17	2.6	Fall River, . .	35	1.6	Woburn, . .	1	0.4
Salem, . . .	18	2.5	Gloucester, . .	8	1.6	Marlborough, .	1	0.4
Haverhill, . .	19	2.4	Holyoke, . .	15	1.6	Total, . .	789	2.01
Boston, . .	273	2.4	Brockton, . .	12	1.4			
Springfield, . .	28	2.1	Quincy, . .	7	1.4			

The total number of deaths from typhoid fever in the 33 cities in the thirty-two years was 17,087. The mean death-rates from this cause in these cities during the past thirty-two years were as follows: —

Death-rates of Cities from Typhoid Fever per 10,000, 1871-1902.

Massachusetts.

1871–75,	8.2	1891–95,	3.4
1876–80,	4.2	1896–1900,	2.6
1881–85,	4.1	1901–2,	2.01*
1886–90,	4.6		

* For the whole State the death-rate from typhoid fever in 1901 was only 1.95 per 10,000, and in 1902 it was only 1.83.

In the State at large the entire number of deaths from typhoid fever in 1902 was only 538, this being the smallest number ever registered in the State in a single year from this cause since the beginning of registration in 1842.

Diphtheria.

The destructive character of this disease has been greatly changed during the past quarter of a century, and the serious epidemics which prevailed in the decade 1870–80 have not recurred since that time. In the five years 1876–80 there were several towns of considerable size in which at least one-third of all the deaths were deaths from diphtheria. This, however, has not been the case for more than twenty years; and, while the disease may be properly termed endemic, according to the common usage of the term, it is rare to find any town or city in which epidemics occur. The following figures show the decrease in the destructiveness of this disease in the period 1876–1902: —

Deaths and Death-rates from Diphtheria, 1876-1902, by Five-year Periods.

Massachusetts.

Years.	Deaths.	Death-rate per 10,000 Living.	Years.	Deaths.	Death-rate per 10,000 Living.
1876-80,	13,676	15.8	1891-95,	7,652	6.4
1881-85,	8,944	9.5	1896-1900,	6,331	4.7
1886-90,	8,857	8.4	1901-02,	2,039	3.5

By the foregoing table it appears that the death-rate from this disease has fallen from 15.8 in 1876–80 to 3.5 in the two years 1901–02, the latter rate being but little more than one-fifth of the former, and also less than that of any five years since the disease was first distinctly recognized in the mortality reports of the State.

How much of this improvement may be attributed to isolation, disinfection and other sanitary measures, and how much to causes still undiscovered and unknown, it is impossible to state. It is quite plain, however, that the decided fall in fatality (ratio of deaths to cases) observed in the past eight years is coincident with and undoubtedly due to the introduction of antitoxin treatment. This is shown not only by figures comprising the deaths and notified cases, but by the confidence with which the general practitioner now regards an average case of this disease, and the hope with which he can usually give assurance of recovery, as compared with the hopeless character of the disease in earlier times. (See report upon Antitoxin in latter portion of this volume.)

Glanders.

An unusual prevalence of glanders among horses and the occurrence of occasional cases among human beings during the past two years renders it desirable to state certain facts relative to the characteristics of this disease and the best methods of preventing it among men. During the two years 1901 and 1902, according to the report of Dr. Peters, Chief of the Cattle Bureau of Massachusetts, 1,482 horses either died from glanders or were killed in consequence of this disease in the State, these cases occurring in 157 cities and towns scattered throughout the State.

The deaths among human beings from this cause were very few, the whole number in the sixty years ended with 1901 being only 30.

Glanders is common to horses, mules and asses, and is communicable to man, these animals constituting the usual source of the disease when occurring in human beings. Persons employed in the care of horses are most exposed to the disease. In 106 cases collected by Bollinger the occupations indicate the source of infection, 41 being hostlers, 11 coachmen, 14 owners of horses, 10 veterinary surgeons, 12 horse butchers, 2 horse dealers, etc. Only 5 per cent. were women, and these were girls employed in stables where there were glandered horses, or were the wives of hostlers and drivers. There was but 1 child among the number, and his father was a coachman.

Infection usually takes place from wounds of the hands, from the conjunctiva, or from the mucous membrane of the nares or throat, these latter places being infected by contact with the nasal secretions of the horse, which are thrown a considerable distance by the frequent snorting of the animal.

Cases are on record, though rare, in which it would happen that the virus entered the system with the food.

While some writers have made a minute classification of the disease, with many subdivisions, there are only two forms which are of practical interest, the acute and the chronic forms.

In acute glanders in man there is at first an indefinite feeling of discomfort, exhaustion, pain in the head and chilly sensations, together with vague pains in the muscles and joints. If the virus has entered the system through a wound in the skin, this often heals quickly without leaving a trace. Often the patient complains of gastric disturbance, indigestion and constipation, which later on gives place to profuse diarrhœa. The liver may become enlarged and painful, and there may be jaundice.

The pulse is usually small and frequent, though occasionally abnormally slow. Temperature, 103° to 104°. There is also a feeling of giddiness, headache, ringing in the ears and sleeplessness.

Later on the pulse becomes weaker, thready, and often increases to 110–140 and more, the temperature rising to 105°. The skin becomes covered with a cold, clammy sweat, consciousness becoming more and more cloudy, till the patient becomes comatose, and finally dies.

Prevention. — The methods of prevention consist mainly in the inspection of animals suspected to be suffering with this disease, their isolation, and slaughter when found to be suffering with the disease. They should not be permitted to mingle with healthy animals or even kept in close proximity to them, after a diagnosis of glanders is established. Attendants who have been in charge of diseased animals should not be allowed to handle healthy animals until cleaning and disinfection of their clothing and hands have been performed.

Attendants should look with suspicion upon all horses having a discharge from the nose, or corded nodules under the skin. They should guard carefully against infecting abrasions of the hands, however slight they may seem, with discharges from diseased horses. Bandages, dressings and instruments which have been used about animals or man affected with glanders are capable of carrying the infection, unless rendered harmless by thorough disinfection.

Stalls from which animals affected with glanders have been removed should be thoroughly cleansed with boiling water; scrapings and sweepings should be scalded and burned. The droppings and the refuse of fodder should also be scalded or burned.

The harness, particularly the bit, should be either thoroughly scalded, or soaked in a five per cent. solution of carbolic acid for a few hours, and then scrubbed with soap and hot water, and dried before being used on a healthy animal.

The carcasses of dead animals should be deeply buried or burned (A. C. Abbott, Hygiene of Transmissible Diseases, second edition, p. 197).

When a local board of health receives notice of the existence of a case of glanders in an animal within the jurisdiction of such board, they should immediately give notice to the State Board of Cattle Commissioners.

In the event of a case occurring in a human being, the local board should notify the State Board of Health, as required by the provisions of chapter 75 of the Revised Laws, section 52.

Other Preventable Diseases.

In addition to the diseases specifically mentioned in the foregoing summary, there are others which are worthy of notice, chiefly in consequence of the fact that each one, with the exception of cholera infantum, shows a marked decrease, when the figures of 1901 and 1902 are compared with those of the earlier five-year periods. The most notable decrease in mortality among the diseases enumerated in this list appears in the columns headed scarlet fever, dysentery and whooping-cough.

Another column might have been added to show the decrease in the diseases incident to child-birth, the mortality from which has fallen from 2 and 2.4 per 10,000 living in the two five-year periods 1866–70 and 1871–75, to 1.4 and 1.2 in the two periods 1891–95, and 1896-1900, or nearly one-half. A better measure, however, of the mortality from this group of diseases is found in comparing them with the number of births (living and still-births together, each case of plural births being counted as one). The average mortality in five years of the early period was .88 of 1 per cent. of the births or labors, and that of five later years was .48 only.

There can be little doubt that a large share of this amelioration or improvement has been wrought by the effect of sanitary measures, very many of which are of a decidedly life-saving character.

Deaths and Death-rates in Massachusetts per 10,000 Living from Certain Infectious Diseases by Five-year Periods, 1866–1900, and for 1901–02.

	Measles.		Scarlet Fever.		Dysentery.		Cholera Infantum.		Whooping-cough.	
	Deaths.	Death-rates.	Deaths.	Death-rates.	Deaths.	Death-rates.	Deaths.	Death-rates.	Deaths.	Death-rates.
1866-70, . .	1,081	1.6	4,670	6.8	3,244	4.7	6,943	10.1	1,481	2.1
1871-75, . .	1,133	1.4	6,782	8.6	2,191	2.8	12,453	15.8	1,561	2.0
1876 80, . .	742	0.9	3,517	4.1	2,366	2.7	9,054	10.5	1,493	1.7
1881-85, . .	1,007	1.1	2,504	2.7	1,601	1.7	9,894	10.5	1,213	1.3
1886-90, . .	1,089	1.0	1,810	1.7	1,276	1.2	10,904	10.3	1,421	1.3
1891-95, . .	815	0.7	2,857	2.4	1,083	0.9	13,426	11.2	1,445	1.2
1896-1900, . .	948	0.7	1,358	1.0	1,434	1.1	11,865	8.9	1,465	1.1
1901, . . .	173	0.6	385	1.3	223	0.8	2,705	9.4	210	0.7
1902, . . .	333	1.1	313	1.1	193	0.7	3,157	10.7	337	1.1

SANITARY LEGISLATION OF 1903.

The following statutes containing provisions relating to public health were enacted in 1903: —

[CHAPTER 305.]

AN ACT RELATIVE TO RETURNS OF RECORDS OF DEATHS BY CLERKS OF CITIES AND TOWNS.

SECTION 1. Section eighteen of chapter twenty-nine of the Revised Laws is hereby amended by inserting after the word "births", in the eighth line, the word: — and, — by striking out the words "and deaths", in the same line, by inserting after the word "births", in the eleventh line, the word: — and, — by striking out the words "and deaths", in the same line, and by adding at the end of said section the words: — The clerk of each city and town shall, on or before the tenth day of every month, transmit to the secretary of the Commonwealth, upon blanks to be furnished by him, certified copies of the records of deaths recorded in such city or town during the preceding month, — so as to read as follows: — *Section 18.* The clerk of each town and of each city containing less than thirty thousand inhabitants shall annually, on or before the first day of March, the clerks of cities containing more than thirty thousand and less than one hundred thousand inhabitants on or before the first day of April, and the clerks of cities containing one hundred thousand inhabitants or more, on or before the first day of May, transmit to the secretary of the Commonwealth certified copies of the records of births and marriages recorded therein during the preceding calendar year, with certified copies, upon blanks provided by the secretary, of all such records and corrections in records of births and marriages as may not have been previously returned. The clerk of each city and town shall, on or before the tenth day of every month, transmit to the secretary of the Commonwealth, upon blanks to be furnished by him, certified copies of the records of deaths recorded in such city or town during the preceding month.

By the terms of this act the work of collecting and tabulating the statistics relating to mortality should be greatly facilitated, since the material forwarded to the central office from each city and town must now be sent monthly, instead of after the close of the year.

[Chapter 306.]

An Act relative to Infected Articles.

Section 1. Section ninety of chapter seventy-five of the Revised Laws is hereby amended by adding at the end thereof the words: — or by the city or town, as the board may determine. For any article of furniture or wearing apparel ordered to be destroyed by an order of the board of health the city or town may recompense the owner to an amount not exceeding fifty dollars, — so as to read as follows: — *Section 90.* The expense of securing, transporting and purifying such articles, as fixed by the board, shall be paid by the owners or by the city or town, as the board may determine. For any article of furniture or wearing apparel ordered to be destroyed by an order of the board of health the city or town may recompense the owner to an amount not exceeding fifty dollars.

[Chapter 358.]

An Act to direct the State Board of Health to investigate the dumping of Garbage and Rubbish in the Harbors and along the Seacoast of Massachusetts Bay, and to report as to the Same.

Section 1. The state board of health is hereby directed to investigate the dumping of garbage and rubbish in the harbors and along the seacoast of Massachusetts Bay, and to report its findings to the general court, with such recommendations as it may deem expedient to provide for the inspection and regulation of such dumping, and to prevent the strewing of the shores with offensive material, whereby a nuisance is created.

Section 2. To carry out the purposes of this act the said board is hereby authorized to expend a sum not exceeding one thousand dollars.

[Chapter 361.]

An Act relative to the Sale of Renovated Butter.

Section forty-eight of chapter fifty-six of the Revised Laws is hereby amended by striking out all after the word "type", in the twentieth line, and inserting in place thereof the words: — Whoever violates any provision of this section shall for a first offence be punished by a fine of not less than twenty-five nor more than one hundred dollars, for a second offence by a fine of not less than one hundred nor more than three hundred dollars, and for a subsequent offence by a fine of five hundred dollars or by imprisonment for not less than sixty nor more than ninety days, — so as to read as follows: — *Section 48.* Whoever, himself or by his agent, or as the servant or agent of another person, sells, exposes for sale or has in his custody or possession with intent to sell, any article or compound which is produced by taking original packing stock or other butter, or both, melting the same, so that the butter fat can be drawn off, mixing the said butter fat with skimmed milk, or milk, or cream, or other milk product, and re-churning the said mixture, or by any similar process, and is commonly known as process butter, shall have the words "*renovated butter*" conspicuously stamped, labelled or marked, in a straight line in printed letters, not less than one half inch in length, of plain, uncondensed gothic type, so that said words cannot be easily defaced, upon the top, side and bottom of every tub, firkin, box or package containing said article or compound. The seller at retail of said article or compound, which is not in the original package, shall himself or by his agent, attach to each package so sold and deliver therewith to the purchaser a label or wrapper bearing in a conspicuous place upon the outside of the package the words "*renovated butter*" in printed letters not less than one half inch in length, in a straight line of plain, uncondensed gothic type. Whoever violates any provision of this section shall for a first offence be punished by a fine of not less than twenty-five nor more than one hundred dollars, for a second offence by a fine of not less than one hundred nor more than three hundred dollars, and for a subsequent offence by a fine of five hundred dollars or by imprisonment for not less than sixty nor more than ninety days.

[Chapter 383.]

An Act relative to Separate Systems of Drainage.

Section 1. The owner of every estate abutting on a public way in which a drain, namely, a conduit for surface or storm water and such waters as shall be specified by the state board of health; and a sewer, namely, a conduit for all other waters and for sewage, all such other waters to be considered sewage, shall have been provided by a city or town, and the owner of any other estate, using any such drain or sewer, shall make or change the plumbing of his estate so that the waters shall be kept separate from the sewage; and shall, as directed by the officer having charge of the maintenance of sewers in such city or town, make connections for, and conduct, the waters into the drain and the sewage into the sewer.

Sections 2 and 3 of this act are special statutes, and relate to the metropolitan district only.

Section 4. The supreme judicial court and the superior court shall have jurisdiction in equity to enforce the provisions of this act.

[CHAPTER 467.]

AN ACT TO PROVIDE FURTHER FOR THE ENFORCEMENT BY THE STATE BOARD OF HEALTH OF THE LAWS RELATING TO THE INSPECTION OF FOOD AND DRUGS.

Section six of chapter seventy-five of the Revised Laws is hereby amended by striking out in the second line, the word "eleven", and inserting in place thereof the word: — twelve, — so as to read as follows: — *Section 6.* The state board of health may annually expend not more than twelve thousand five hundred dollars for the enforcement of the provisions of sections sixteen to twenty-seven, inclusive; but not less than three fifths of said amount shall be annually expended for the enforcement of the laws against the adulteration of milk and milk products.

By the foregoing act the appropriation annually granted for the enforcement of the food and drug statutes is increased from $11,500 per year to $12,500. This increase was necessitated chiefly in consequence of the enactment of chapter 110 of the Acts of 1902, whereby the powers and duties of the inspector and assayer of liquors were transferred to the State Board of Health.

[CHAPTER 480.]

AN ACT RELATIVE TO THE PRODUCTION AND DISTRIBUTION OF ANTITOXIN AND VACCINE LYMPH.

SECTION 1. Section four of chapter seventy-five of the Revised Laws is hereby amended by inserting after the word "institutions", in the eleventh line, the words: — and may, for the use of the people of the Commonwealth, produce and distribute antitoxin and vaccine lymph, — so as to read as follows: — *Section 4.* Said board shall take cognizance of the interests of health and life among the citizens of the Commonwealth, make sanitary investigations and inquiries relative to the causes of disease, and especially of epidemics, the sources of mortality and the effects of localities, employments, conditions and circumstances on the public health, and relative to the sale of drugs and food and the adulterations thereof; and shall gather such information relative thereto as it considers proper for diffusion among the people. It shall advise the government relative to the location and other sanitary conditions of any public institutions; and shall have oversight of inland waters, sources of water supply and vaccine institutions, and may, for the use of the people of the Commonwealth, produce and distribute antitoxin and vaccine lymph. It shall annually examine all main outlets of sewers and drainage of cities and towns of the Commonwealth, and the effect of sewage disposal, and shall annually report thereon to the general court, with such recommendations for the protection of the interests of persons and property and for the prevention of offensive odors and objectionable conditions as it considers expedient.

MANUAL OF HEALTH LAWS.

In consequence of the size and expense of the edition of Revised Laws of the Commonwealth, and the fact that amendments are enacted every year, it was deemed advisable to publish a manual of the laws relating to public health, for the use of local boards of health; and for this purpose a first edition of this manual was prepared and published in 1882, and a new edition has been issued about as often as once in three or four years since that time.

The publication of the present edition has been legalized by an act of Legislature (chapter 230, Acts of 1902), which authorizes the Board "to publish not oftener than once in three years, beginning with the year nineteen hundred and two, a manual of the laws relating to boards of health in this Commonwealth, together with such other information upon the same subject as the board may deem expedient, the same to be distributed among the local boards of health throughout the Commonwealth."

This manual contains, in addition to the statutes relating to public health which appear in the new edition of Revised Laws of 1902, all of the decisions of the supreme court relative to these statutes which have been made previous to July, 1903. It also contains all of the health legislation of 1902 and 1903, together with other matters pertaining to public health, which will make it a convenient handbook for all health officials, as well as for medical examiners, physicians and persons engaged in the sale of food products.

A portion of the same manual, containing the laws of the State relative to the sale of food and drugs, will also be issued in a separate form, for the use of persons engaged in the sale of such articles.

The present edition will be completed and ready for distribution during the month of November of the present year (1903).

Health of Towns, and Medical and Sanitary Inspection.

During the past five years the Board has maintained a medical and sanitary inspector, whose duties are defined in the following vote of the Board of July 7, 1898: —

> That a new officer in the administrative and advisory work of the Board be appointed, whose duties shall be controlled by the following regulations: the special function of this officer shall be the collection of information relating to the public health of Massachusetts; the investigation of local epidemics in this Commonwealth; the establishment and maintenance of closer relations between the Board and local boards of health; and the determination, by skilled inquiry, of the causes of abnormally high death-rates.

In accordance with this plan, Dr. F. L. Morse was appointed by the Board in 1898 as its medical and sanitary inspector, and has carried out the work laid down in this order of the Board continuously since 1898. The work of this department has proved an efficient aid in the investigation of the causes of disease, and especially in the prevention of their spread. During the recent epidemic of small-pox an unusual amount of work was accomplished in this direction, as may be seen by consulting that portion of this report which relates to the health of towns; and efficient aid was rendered to local boards of health, especially in the smaller towns, which are not so fully equipped for sanitary work as the cities and larger towns.

By this means also the State and local boards of health are brought into closer and more harmonious relation. Another circumstance which has greatly facilitated the progress of sanitary work in Massachusetts is the organization known as the Association of Boards of Health, which meets quarterly, and affords an excellent means for interchange of opinions upon all the various topics which relate to public health administration. This organization is open to all persons who are interested in sanitary work.

Water Supply and Sewerage.

The duties of the Board under the provisions of the sections of chapter 75 of the Revised Laws relating to the pollution of water supply and its sources, and under general and special acts relating to water supply, sewerage and sewage disposal and kindred subjects, have been materially increased by legislation in recent years. A portion of these duties are advisory, others are experimental, while others still relate to the examination of water supplies, ice supplies and rivers, the establishment of rules for the sanitary protection of water supplies, the examination of sewer outlets and of flats and waters from which shell-fish are taken, and the prevention of the pollution of the Neponset River.

This work is carried on under the direction of the committee on water supply and sewerage of the Board.

Advice to Cities and Towns. — During the year 1902 ninety-three applications have been presented to the Board for advice with reference to water supply, sewerage, ice supply, and the prevention of the pollution of streams, including two applications for rules and regulations for the sanitary protection of water supplies and one for approval of the location of a public institution. A copy of the record of the action of the Board in each of these cases will be found on pages 1–89 of this report.

Examinations of Water Supplies. — The waters of nearly all of the sources of public water supply of cities and towns of the State have been examined at least once during the year, by means of a chemical analysis of samples of the water sent to the laboratory of the Board by the water works authorities. The total number of sources of public water supply in use in the State is about 245. In cases where the source is a new one, or the water is liable to change in character, samples have been collected once a month and sometimes even more frequently during a portion of the year. In other cases, where the water appears to change but little from time to time, only occasional samples have been examined. Nearly all of the samples of waters of ponds and reservoirs are examined microscopically, as well as chemically, to determine the quantity and condition of organic matter present therein.

The results of the examinations of water supplies are summarized in the chapter entitled "Examination of Water Supplies," pages 91–163. In most cases only the average of the analyses is presented, together with an average of the analyses of previous years, for comparison. In cases where the results of the analyses are of general interest and value, the results are presented in full.

Sanitary Protection of Water Supplies. — Under the provisions of the Revised Laws, the State Board of Health is authorized to make rules and regulations for the purpose of preventing the pollution and securing the sanitary protection of all streams and ponds used by a city, town, water or ice company as sources of water supply, together with all springs, streams and water courses tributary thereto; and during the past year, in response to petitions, rules and regulations have been adopted by the Board for the sanitary protection of the water supplies of Rockport and Taunton. These rules are similar to those previously made in the cases of Danvers, Haverhill, Salem, Marlborough, Norwood, Cambridge and the metropolitan water district. The Legislature has made no definite appropriation for carrying out the provisions of this act, and there is, consequently, no practicable way by which the Board can enforce rules and regulations under the authority of the present statute, and their enforcement is necessarily left to the local authorities.

The shores of many of the lakes and ponds of the State used as sources of public water supply are becoming occupied to a greater and greater extent as places of residence in the summer season, and the free use of such ponds and lakes by large numbers of people for pleasure purposes in summer is a grave danger to the health of the people who use the water for drinking.

The duty of protecting the public which uses the water of such sources for drinking is imperative, and it is practicable to protect adequately most of the sources of water supply in use in the State at the present time by the enforcement of sanitary rules.

The difficulty experienced in some cases in protecting the purity of the water of ponds and reservoirs having dwelling houses in the immediate neighborhood of their shores shows the advantage possessed by those cities and towns which have secured control of the lands about their sources of supply.

The usual tables of water supply statistics are presented, including records of rainfall and of the flow of several carefully measured streams. The summer season of 1902 was an exceptionally cold one, and the flow of streams was somewhat less than the normal, as indicated by the flow of the Sudbury River.

The investigations relative to rivers have been combined with the examinations of sewer outlets, and are presented in a subsequent portion of the report.

Experiments upon the Purification of Sewage and Water at the Lawrence Experiment Station. — A short summary of the results of the investigations made during the year at the Lawrence Experiment Station upon the purification of sewage and water is presented in a report by the chemist of the Board, pages 177–242, inclusive. During the first years of operation of this station the investigations were chiefly directed to the purification of sewage by intermittent sand filters, and to establishing a knowledge of the fundamental principles of successful sewage treatment, — a then little-understood subject. Many intermittent sand filters are now in operation in this State and elsewhere, successfully purifying the sewage of cities and towns. Studies were begun at the station in the earlier years upon rapid methods of sewage purification. Of late years this subject has assumed greater importance elsewhere, especially in England and Germany, and a great amount of attention has been given to it at the station. These studies include investigations upon the preliminary treatment of sewage before its application to filters. Contact filters, intermittent continuous filters, coke and coal strainers, and septic tanks and their operations, are under investigation. The effluents produced by the coarse filters, operated at high rates, vary so greatly in character, according to the nature of the material of which the filter is constructed and the manner in which it is operated, that many special studies are made necessary to determine the efficiency and permanency of such filters. During the year a study was made of the treatment of dye-house waste, etc., and much information along this line gained. This is not summarized in this report, however, as the investigation is being continued at the present time.

Studies of the efficiency of sand filters in the purification of water have been continued, and the work of the Lawrence city filter in removing bacteria from the river water applied to it and the effect of the use of this filtered water upon the health of the city carefully noted. Studies of the importance of the bacterial examination of water of different classes have been continued, and a paper is presented upon page 243, summarizing the work along this line during the past seven years. This paper also includes some studies upon the relative viability of B. coli and B. typhosus under a variety of conditions. Considerable work has also been done during the past two years in the investigation of bacterial methods for the determination of the pollution of shell-fish gathered from various sources.

Examination of Sewer Outlets and of the Condition of Rivers and Other Waters affected by Sewage Disposal. — By the provisions of chapter 104 of the Acts of the year 1901, the State Board of Health is required to examine annually all main outlets of sewers and drainage of the cities and towns of the Commonwealth, and the effect of sewage disposal, and annually report thereon to the General Court, with such recommendations for the protection of the interests of persons and property as said Board shall deem expedient, and for the prevention of offensive odors and objectionable conditions.

In the same year the Board was authorized to examine complaints with regard to the contamination of tidal waters and flats by sewage or other causes, and to regulate the taking of shell-fish from polluted waters.

These two acts are quite closely related, and the work has been carried on under them simultaneously. The results of the investigations made in the year 1901 have already been presented in a previous report.

The results of the examination of sewer outlets and the effect of sewage disposal relate quite closely to the sanitary condition of the various streams and inland waters of the State, and, in connection with the investigation of sewer outlets, an examination has been made of all of the various streams in the State which are polluted by the direct discharge of sewage. The results of these investigations are presented in a report upon the "Examination of Sewer Outlets and the Effect of Sewage Disposal."

The objectionable conditions caused by the discharge of sewage into the sea and the inland waters of the State are mainly of two classes: (1) those which are caused by faulty construction or location of the sewer outlet; and (2) those which are caused by the discharge of an excessive quantity of sewage into a harbor or stream, thereby polluting the water to such an extent as to make it offensive for a long distance from the sewer outlet.

The nuisances caused by faulty construction or location of sewer outlets are in nearly all cases local, and affect only the people of the community maintaining the outlet. They are remediable by the cities and towns owning and maintaining the sewer outlets.

The objectionable conditions caused by the gross pollution of the water of streams affect in many cases other communities than those which cause the nuisance.

The most objectionable conditions existing in any stream in the Commonwealth, all things considered, are to be found in the Blackstone River, the condition of which is about the same as it was in the years before works were first installed for the treatment of the sewage of the city of Worcester. By the action of the Legislature in 1886 the city of Worcester was directed to purify its sewage; and further action has been taken in the courts by the communities living on the river below Worcester, to secure the carrying out of the provisions of this act. As indicated in this report, a great amount of work has been and is being done by the city in carrying out the requirements of the act of 1886.

The Neponset River, which is also a very badly polluted stream throughout the greater portion of its length, has been the subject of action by the Legislature, with a view to preventing the entrance of sewage into the stream and the discharge therein of objectionable manufacturing refuse until it has been purified.

The North Branch of the Nashua River, which is greatly polluted by the sewage of Fitchburg and Leominster, and is offensive to sight and smell for a large part of its length, is probably next in order the most objectionable case of stream pollution in the State. Plans are already being prepared by the communities which cause the serious pollution of this stream, which, if carried out, will remove the objectionable conditions here.

A similar condition of gross pollution exists in the Hoosick River below

North Adams; and the objectionable condition of the Hoosick River will continue to grow worse with the growth of the city of North Adams, until the sewage is purified before being discharged into the stream.

The limit of time within which sewage may be discharged into the Mill River at Northampton under the act authorizing the construction of a sewerage system in the city will be reached in the latter part of 1904, and it is likely that the sewage of Northampton will be removed to a suitable outlet before that time.

At Easthampton also the objectionable conditions caused by the present method of disposal of sewage are likely, by the carrying out of the provisions of a recent legislative act, to be soon removed, by the diversion of the sewage from the present outlet and by the purification of the sewage.

At Pittsfield much of the sewage of the city, which was formerly the chief cause of objectionable conditions in the Housatonic River, has been diverted to the new purification works; and, with the completion of the sewerage system and its extension to include the manufacturing wastes in the city, the further offensive pollution of the Housatonic River in this region will be removed.

At Webster the provisions of the act authorizing the construction of a system of sewerage for the town provide for the purification of the sewage, including the objectionable manufacturing wastes which are the great cause of the pollution of the French River.

Plans for the purification of the sewage of Middleborough, which greatly pollutes the Nemasket River, and of Attleborough, which greatly pollutes the Ten Mile River, were considered by these towns several years ago, but nothing further has been done.

The gross pollution of the Charles River at Milford will greatly increase if sewers are extended in the town, unless purification works are established.

A recommendation relative to the prevention of the pollution of the Sudbury River was presented to the Legislature in 1901.

In the cases of other streams which are polluted by sewage the pollution has not yet become so great as to make the water of the stream objectionable to sight or smell, unless in the immediate neighborhood of sewer outlets.

Since 1886, the year when the act for the protection of inland waters was passed, it has been necessary for cities and towns intending to introduce systems of sewerage or sewage disposal to submit their proposed plans for the advice of the State Board of Health; and nearly all of the acts of the Legislature relating to sewerage which have been passed within the last few years have contained provisos requiring the approval of plans of sewerage and sewage disposal by this Board before the construction of sewerage works.

In approving plans of sewerage and sewage disposal under these special acts, the Board has, in all cases where objectionable pollution of a stream by sewage was liable to result, required the purification of the sewage, either in the beginning or after a term of years.

Two cases of gross pollution of streams — those of the Blackstone and the Neponset — have been dealt with directly by the Legislature.

The worst cases of pollution of streams now existing, excepting the Blackstone and Neponset rivers, are those caused by the sewage discharged from cities and towns which have constructed sewers under the general laws or acts which do not require the consideration of the plans by the State Board of Health.

Of the nuisances caused in this way, some of the more serious are those in the Charles River at Milford, the Ten Mile at Attleborough, the North Branch of the Nashua River at Fitchburg and Leominster, the Hoosick at North Adams and the Nemasket at Middleborough. In these places the sewerage systems are being enlarged and used to a greater extent from year to year, and the objectionable conditions caused by the sewage are growing worse.

In some of these cases some preliminary action with a view to removing the sewage from the streams has been taken; but, unless the cities and towns causing these nuisances take action toward preventing them, the objectionable conditions cannot be removed unless action is taken by the Legislature.

Under present conditions, some cities and towns have made a large outlay in order that a stream may be kept clean, while others, under similar circumstances, evade the expense of caring properly for their sewage, and allow it, in most cases, to pollute the water course most convenient for use as a sewer outlet.

Food and Drug Inspection.

The law which was enacted in 1882, to prevent the sale of adulterated food and drugs in Massachusetts, has now been in operation for more than twenty years, the State Board of Health having begun work under the provisions of this act in the winter of 1882–83. All of the general acts and amendments relating to this topic are now embodied in chapter 75 of the Revised Laws, and many other statutes relating to special articles of food are also to be found in chapter 56 of the Revised Laws.

For the purposes of this act the Board employs three chemists and three collectors of samples, all of whom devote their entire time to the work, under the direction of the secretary. The collectors are authorized to enter complaints at court for violations of the law.

The details of this work for the year ended Sept. 30, 1902, may be found in that part of the present volume entitled "Food and Drug Inspection," wherein it appears that 10,470 samples of food and drugs were examined during the year, bringing up the total number examined since work was begun, in 1883, to 138,309.

The average expense of collection, examination, etc., per sample for the whole period was $1.42, this expense having been reduced from $2.26 per sample in 1883 to $1.12 in 1902.

The whole number of prosecutions made during the year was 76, of which 74 resulted in conviction. The total number of prosecutions made in the entire period of twenty years was 1,647, of which number 1,526, or 92.6 per cent., resulted in conviction.

By an act of 1902, the office of assayer of liquors was abolished, and the duties of this official were transferred to the State Board of Health. The examination of all samples sent for analysis under the provisions of this act from the local authorities of cities and towns is performed in the food laboratory at the State House.

The Production of Vaccine Lymph and Diphtheria Antitoxin.

While the epidemic of small-pox of 1901–02 was at its height, several questions relating to vaccination were presented to the legislative committee upon public health, and a bill (House, No. 1369) was introduced April 25, 1902, "To provide for an investigation and report by the State board of health as to the production and free distribution of vaccine lymph." On May 22, 1902, the following resolve was enacted (House, No. 1466): —

Resolve to provide that the State Board of Health shall investigate the Production of Vaccine Lymph in this State, and also report a Plan for its Production and Free Distribution.

Resolved, That the state board of health be authorized and requested to report to the general court as soon as possible a plan for the production and distribution of pure vaccine lymph for free use in this Commonwealth; and also to report as to the quality of the vaccine lymph in use in this Commonwealth during the past winter and at the present time, and as to the quality of the vaccine lymph produced or sold by private persons or corporations in this state, and the methods and conditions by and under which it is produced.

To this resolve the Board replied as follows (House, No. 1522): —

Office of the State Board of Health, State House.

To the House of Representatives.

In reply to the legislative Resolve, No. 1466, relative to an investigation of the production of vaccine lymph and a plan for its production and free distribution in Massachusetts, the State Board of Health respectfully submits the following report: —

We recommend that the plan which has been successfully used by us for the production and free distribution of the antitoxin of diphtheria since 1895 be also employed for the production and distribution of vaccine. The plan involves the construction of a building for the animals, to be used for their vaccination, for the preparation of the vaccine, and for their slaughter after the vaccine is collected and before it is distributed.

After the vaccine is collected it should be sent to the office of the Board, and distributed to local boards of health in the same manner as the antitoxin of diphtheria is now distributed. Under the best conditions, such as prevail in thoroughly vaccinated countries, where epidemics of smallpox do not occur, the production of vaccine should be uniform and continuous, and the demand would depend upon the birth-rate.

Of the nearly 3,000,000 of population of the State, probably 90 per cent. are vaccinated, and the majority of these have also been revaccinated in the present epidemic. The future demand should not be based upon the population, but upon the birth-rate, assuming that vaccination is thoroughly carried out by local sanitary officials.

There would be then required an annual product necessary to vaccinate about 150,000 persons annually, distributed as follows: —

Children one year of age,	60,000
Arriving at age of ten years (revaccinated),	50,000
Immigrants requiring vaccination,	40,000
	150,000
For the expenses of building such an establishment the Board submits the following estimate,	$20,500
For yearly maintenance, including cost of animals, feed, salaries of employees, supplies of material for vaccine production and expenses of distribution,	6,500

So far as can be learned by the Board, the supply of vaccine material used in Massachusetts during the past winter and at the present time has been procured mainly from sources outside the State. The distance of these sources from Massachusetts, and the fact that very much of the supply is sold by agents and middlemen, make this method a source of frequent complaint. Some, but not all, of the producers appear to be working under favorable modern conditions; but this does not alter the fact of their distance, and the frequent difficulties of obtaining fresh vaccine when it is most wanted.

With reference to the production of vaccine by private parties in Massachusetts, there are, so far as we can learn, only two such establishments now in operation in the State, neither of which appears to be conducted upon methods and under conditions which are now practised by the best authorities. The product of these establishments appears to have been decidedly diminished by the competition of outside parties.

A vaccine lymph, in order to fulfil the requirements demanded by such an important procedure as the immunization of a community safely and efficiently against small-pox, should be of such quality as to give typical vaccine vesicles in over 90 per cent. of all susceptible individuals. At the same time it should be, as far as the most advanced knowledge can make it, free from danger to the health and life of the vaccinated individual.

1. The relative efficiency or taking quality of any given vaccine can be determined only by carefully collected statistics of the cases vaccinated with it. Such statistics must inform us whether the cases were primary or revaccination cases, since persons vaccinated once or oftener react somewhat differently from those not yet vaccinated.

2. The purity or safety of a vaccine may be endangered: —

(*a*) By certain infectious diseases of the calf (skin eruptions, tuberculosis, diarrhœa, etc.) yielding the vaccine; and

(*b*) By the introduction of extraneous infectious agents from the surroundings of the animal (stable, feed, attendants, etc.), or an impure lymph used to inoculate the calf or cow.

To determine, therefore, the purity and especially the age of vaccine used during the past winter in this Commonwealth would be a physical impossibility.

Vaccine from a number of establishments situated in other States was used in Boston alone during the winter, and only the glycerinated vaccine could be considered as still effective. The purity of this at the present time would be no index of its bacterial contents during the winter, as the glycerine slowly destroys the bacteria. Its efficiency could not be tested, as the vaccine itself also slowly degenerates. Nothing could be learned concerning the condition of the calves used during the winter, nor to what extent extraneous infection was avoided.*

Any inquiry concerning vaccine in use at the present time would be equally barren of results. The animals in establishments outside the State could not be inspected before use or examined after death. Any examination of the bacterial contents of the vaccine would have only a relative value, since it is the kind rather than the number of bacteria which determines the good or bad quality of any vaccine, and the determination of the kind of bacteria is a long and complicated process.

To determine the condition and purity of vaccine used at present, it would be necessary for the Commonwealth to send inspectors to the various establishments having vaccine on sale in this State, to note the condition of the animals and to witness the autopsy of those that have been used. It would be necessary to examine the employees, and perhaps even to inquire into the general scientific capacities of those in charge of such establishments. An examination of the vaccine itself would necessitate an enlargement of the present laboratory and the employment of another bacteriologist. Even then, the testing of so many specimens from many animals would not pay for the outlay, as it would be a wasteful process, which would not accomplish the end sought.

When we come to the vaccine establishments in this State, the situation is precisely the same. Only the continual presence of an inspector would give the State full information of the quality of the vaccine. No amount of costly and detailed examination of the final product will enable any one to analyze the method used in preparing it, simply because microscopical and bacteriological methods are inadequate to do more than to give a general and somewhat uncertain estimate of the care used in its preparation. The fact that the microbe producing vaccinia cannot be seen with the microscope, and that it cannot be studied with bacteriological methods, makes the whole subject of vaccine production a difficult one, and not to be controlled at a distance. Owing to the many minor modifications adopted by the different establishments, both in Europe and in our own country, in the manufacture of vaccine lymph, it would be necessary for any State inspection to arbitrarily prescribe certain definite methods to be followed by manufacturers coming under the jurisdiction of the State. Such prescription of methods would be a practical assumption of responsibility by the State, and would probably make the business unprofitable, unless all vaccine products made outside of the State were excluded from competition.

But the process of preparing vaccine lymph has not yet reached that state of perfection in which rigid rules can be formulated. A certain latitude must be allowed, as a means towards greater perfection. In short, the preparation of vaccine lymph cannot be inspected successfully nor the product tested satisfactorily without reference to its preparation; and, in the opinion of the Board, every detail in this preparation must be made subject to a constant and competent supervision, which would be difficult within the State and impossible outside of it.

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* The presence of the bacilli of tuberculosis could scarcely be determined, owing to the large amount of glycerine in the glycerinated lymph. Even if it were attempted to find them, it would require three to four weeks to obtain any results from the inoculation of animals. The only satisfactory method to determine the presence of tetanus bacilli in the lymph would be a very difficult problem, owing to the nature of the tetanus germ. Such dangerous organisms can only be excluded by closing up all possible ways in which they may be conceived of as entering the vaccine.

By order of the State Board of Health,

SAML. W. ABBOTT,

Secretary.

The subject was finally referred to the State Board of Agriculture by the following resolve, enacted June, 1902: —

> *Resolved,* That the state board of agriculture is hereby authorized and directed to investigate as to the feasibility and probable cost of producing vaccine lymph at the Massachusetts agricultural college, for free distribution within the Commonwealth, and to report the result of such investigation, together with such recommendations as the board may consider advisable, to the general court on or before the fifteenth day of January in the year nineteen hundred and three.

The production of diphtheria antitoxin has been conducted by the Board for the past eight years, the product having been distributed to boards of health throughout the State. It has undoubtedly proved a great aid in diminishing the fatality of this disease, and in the consequent saving of human life, especially among those who could not afford to pay for the product at the prices usually charged for it. A full report upon this subject appears in this volume, in which it is shown that 33,475 bottles or packages of 1,500 units each were issued during the year, this amount being 6,736 less than were distributed in the preceding year, in consequence of a diminished prevalence of the disease.

The progress of bacteriological diagnosis among local boards of health during the same period of eight years has evidently wrought a change in the use of diphtheria antitoxin, since on consulting the full file of reports for the eight years it appears, on comparison of the early and late years of the period, that in the first two years of the use of the Board's antitoxin in the State (1895–96) the cases which were determined to be positive and were treated with antitoxin constituted only 43.7 per cent. of all cases treated. On the other hand, the ratio of such cases treated in the last two years (1901–02) constituted 74.9 per cent. of all cases treated.

The fatality of such cases determined to be positive was only 9.9 per cent.; while the fatality of cases in which no bacteriological examination was made was, for the whole period of eight years, 12.6 per cent.; the reason for the difference being the fact that a considerable number of neglected cases is brought to the attention of the hospital authorities and of general practitioners when such cases are *in extremis*, and bacteriological examination is of little avail, but antitoxin treatment is employed as a last resort. Hence the increased fatality of this class of cases.

Baking Powders.

During the legislative sessions of 1901–02 several questions relating to the healthfulness of baking powders and the regulation of the sale of such products were brought to the attention of the Legislature. In 1901 the question came up in the form of an order, addressed to the State Board of Health, April 29, 1901, directing the Board to transmit answers to the following questions (House, No. 1387): —

> *First.* — What articles of food or drink and what articles that enter into food or drink sold or offered for sale in this Commonwealth contain any salts of copper, and are said salts of copper in the combination specified deleterious to health?
>
> *Second.* — What articles of food or drink and what articles that enter into food or drink sold or offered for sale in this Commonwealth contain any salts of aluminum, and are said salts of aluminum in the combination specified deleterious to health?
>
> *Third.* — What articles of food or drink and what articles that enter into food or drink sold or offered for sale in this Commonwealth contain any salts of zinc, and are said salts of zinc in the combination specified deleterious to health?
>
> James W. Kimball, *Clerk.*
>
> A true copy: Attest:
>
> James W. Kimball, *Clerk.*

To these inquiries the Board replied as follows: —

First. — Copper salts have been found by the Board in many instances in canned vegetables, mostly of French origin, the object of the addition being to give the vegetables a fine green color. The Board has examined a large number of samples in the last thirteen years, and in the year 1891 made a systematic examination of all the French brands procurable in the Commonwealth, with the following results: —

Character of Goods.	Number in which Copper was found.	Number free from Copper.	Total Samples examined.
French canned peas,	63	13	76
French canned string beans,	10	4	14
French canned Brussels sprouts,	3	–	3
	76	17	93

The amount of copper found was as high in one instance as 2.75 grains per can, and averaged about 2 grains.

The Board has taken the position that copper salts are deleterious to health, and that their presence in food products cannot be permitted.

Copper has also been found in some cases where its presence was doubtless accidental, as, for instance, in pickles or canned tomatoes, which had been boiled or prepared in copper kettles.

Second. — Salts of aluminum have been found by the Board in pickles (added, it is said, to give crispness), as an adulterant in cream of tartar, and as an essential ingredient in some baking powders. Its use in pickles is not at all common; its addition to cream of tartar is to be regarded as a cheap substitute, since, like cream of tartar, it has leavening power when used with an alkaline bicarbonate.

When baking powders containing salts of aluminum are used for making bread, biscuits, cakes, etc., the aluminum compounds remain in the bread in a somewhat altered condition, but from the facts at its disposal the Board is unable to express a definite opinion whether bread and similar products, as ordinarily made with baking powders of this character, are deleterious to health.

Third. — Zinc salts are very seldom found in food products in Massachusetts. Instances of the presence of zinc in dried apples were referable to the fact that the apples were dried on galvanized sheet iron.

The Board has investigated the question of the presence of zinc in drinking water supplies where galvanized iron pipes are used, first in 1874 and recently in 1899. Except in the case of the use of some ground waters, containing very large amounts of free carbonic acid, which dissolves zinc and many other metals very freely, the amount of zinc found in ordinary water supplies, where galvanized pipes are used, is not sufficient, in the opinion of the Board, to give anxiety.

HENRY P. WALCOTT,
For the State Board of Health.

In 1902 the subject was again brought to the attention of the Legislature, and an order was issued directing the State Board of Health to "make a scientific and thorough physiological investigation of the healthfulness of baking powders, making such tests as will demonstrate whether or not any brands of baking powder on sale in this Commonwealth are prejudicial to health; and whether the introduction into food of an article in small quantities, which ordinarily would be harmless, would, when taken by a person in feeble health or dietetically disordered, eventually undermine the system; and that said Board make such recommendations to the next General Court as the result of said investigation shall in its opinion warrant." To this order the Board replied as follows: —

The Board would respectfully reply that it has been unable to carry out the order of the General Court, owing to the very great difficulties which such an examination presents. An investigation of this character which would lead to results that would be conclusive and indisputable, and which would enable this Board to make a definite report to the Legislature, would involve the expenditure of a large amount of money for a special laboratory, and for the services of physiological chemists who could have under their complete control for a considerable period of time many men, women and children, determining the condition of their organs of digestion and excretion, and analyzing all the food they consumed, and as well all their excreta. This could only be done in a large public or private institution, and could only be carried out with the consent and co-operation of those on whom the experiments were tried. While such an investigation under these conditions would be feasible, it must be said that it has not hitherto been the practice of the State to experiment on persons under its care and control.

In the opinion of the Board, experiments on animals would not yield information which would be conclusive with regard to man.

Illuminating Gas.

In consequence of the great frequency of deaths from gas poisoning which have occurred since the repeal of the act limiting the amount of carbonic oxide in illuminating gas, a legislative hearing was given during the session of the General Court, and the following questions were submitted by the Legislature to the State Board of Health on March 24, 1902. The reply of the Board, together with the questions submitted by the Legislature, was as follows (House, No. 1256): —

Office of State Board of Health, State House,
Boston, March 31, 1902.

To the House of Representatives, State House, Boston.

I have the honor to submit herewith the reply of the State Board of Health to the questions submitted to the Board by your honorable body on March 24, 1902.

Respectfully submitted,
Samuel W. Abbott,
Secretary State Board of Health.

Office of State Board of Health, State House,
Boston, March 31, 1902.

Replies to questions submitted to the State Board of Health by the Legislature, March, 1902: —

1. What is the most dangerous element of illuminating gas?

Carbonic oxide.

2. What per cent. of this element is contained in coal gas?

About 7 per cent.

What per cent. in water gas?

About 30 per cent.

3. Is the dangerous nature of the gas increased in proportion to the increase in per cent. of this element?

Yes.

4. How is death caused by inhalation of water gas? State physiological action.

Death is caused by changes in the chemical composition of the blood, by the substitution of poisonous carbonic oxide gas for the oxygen which is normally contained in the blood.

5. How is death caused by inhalation of coal gas? State physiological action.

While less in degree, the action is the same as in water gas.

6. Is it more difficult to detect a leaking pipe when water gas is used than when coal gas is used?

No.

7. If a person is asphyxiated by illuminating gas, does the danger increase in proportion to the carbonic oxide it contains?

Yes.

8. What are the chances of recovery, after removal from the source of poisoning, of a person asphyxiated by coal gas? Water gas?

Other things being equal, the experience in Massachusetts shows that the chances of recovery under exposure to escaping coal gas are many times greater than they are under similar exposure to escaping water gas.

9. Which is it easier to blow out the flame from, coal or water gas? Why?

We do not know.

10. Has there been an increase or decrease in the number of deaths from gas poisoning since the introduction of water gas?

A very decided increase.

11. If there has been an increase or decrease, what is the per cent. of increase or decrease?

In the thirteen years *previous* to the introduction of water gas in Massachusetts (1876–88) the number of deaths registered as due to poisoning from illuminating gas was 8. The foregoing deaths were, so far as can be learned, caused by the inhalation of illuminating coal gas. In the thirteen years *following* the introduction of water gas (1889–1901) the number of deaths registered as due to illuminating gas poisoning was 459.

12. Has the danger from broken or leaking pipes or mains increased or diminished since the introduction of water gas?

It has increased.

13. What per cent. of carbonic oxide is a safe limit for illuminating gas to contain?

Further than has been already said in answer to Question 3, that the danger increases with the amount of carbonic oxide present, the Board does not know that there is any safe limit.

14. What is the difference in effect of carbonic acid gas and the carbonic oxide of illuminating gas? State physiological effect.

Carbonic acid gas produces asphyxia by interference with respiration and with the renewal of the blood by aeration in the lungs; the carbonic oxide gas of illuminating gas effects a chemical poisoning of the blood, taking the place of the oxygen carried in the blood corpuscles, and rendering the blood unfit to support life.

15. State number of deaths from gas poisoning in Boston for the last ten years. How does this number of deaths from gas poisoning in the city of Boston for the years 1898 and 1899 compare with the deaths of the last two years, 1900 and 1901?

The number of deaths recorded as due to poisoning from illuminating gas in Boston in the ten years, 1892–1901, was as follows: —

In 1892,	14	In 1898,	58
In 1893,	23	In 1899,	51
In 1894,	25	In 1900,	25
In 1895,	33	In 1901,	14
In 1896,	42		
In 1897,	45	Total,	320

The deaths from this cause in Boston in 1898 and 1899 were	109
Those in 1900 and 1901 were	39

16. Is there any relation between the deaths occurring in these various years and the increased or decreased use of coal and water gas?

Yes.

17. If there is, what, in your opinion, is the relation?

That of cause and effect, the greater number of deaths corresponding to the increased use of water gas.

18. Does the continuous absorption of gas in quantities not sufficient to cause asphyxiation tend to the development of disease, such as consumption or heart disease, or may it undermine the system so that these or other diseases may find it easy of attack?

In the present state of our knowledge, a definite answer to this question is not possible.

19. Is there any difference between the effect of coal gas or water gas in this regard?

We do not know.

20. Can coal and water gas be mixed so as to bring the per cent. of carbonic oxide down to a safe point?

We have not been able to ascertain this fact by experiment.

HENRY P. WALCOTT,
GERARD C. TOBEY,
F. W. DRAPER,
JULIAN A. MEAD,
CHAS. H. PORTER,
HIRAM F. MILLS,
JAMES W. HULL,
State Board of Health.

RESIGNATION OF DR. DRAPER.

Dr. F. W. Draper, a member of the Board since its reorganization, having resigned in July, 1902, the Board voted to place upon its records the following statement in recognition of his valuable services: —

> Dr. F. W. Draper, a member of the Board since its reorganization in 1886, has felt himself obliged to resign his place. This Board now places on record its regret for the loss of a much-esteemed associate, a highly qualified and devoted expert in all questions affecting the public health.

ROUTINE WORK OF THE BOARD.

During the year ended Sept. 30, 1902, the Board held meetings as often as once a month, and meetings of its standing committees were held as often as were necessary for the transaction of special business. Hearings were held at the office of the Board with reference to the sewerage and sewage disposal of Taunton, on Jan. 2, 1902, and at the City Hall in Taunton on Jan. 22, 1902.

On June 5 the Board visited Pittsfield, held its annual meeting in that city, and visited the new sewage works of the city.

The office of the Board has been open throughout the year, as prescribed by the Revised Laws, chapter 18, section 13, "for the transaction of its authorized business." Advice has been very frequently given at the office and by mail to local boards and to individuals in regard to sanitary matters, and many visits have been made by the officials of the Board to cities and towns for the purpose of making investigations and giving advice.

The office of the Board is virtually a central station for the distribution of the antitoxin produced by the Board, and for the various culture tubes, receptacles and other means employed for the diagnosis of disease. For this purpose the office of the Board has been open throughout the year on such days and at such hours as are prescribed by the statutes; and the existence of a central office of this character has proved a most efficient aid to those boards of health which could not maintain local laboratories of their own.

STATISTICAL TABLE FOR THE YEAR ENDED SEPT. 30, 1902.

Whole number of samples of food and drugs examined during the year,	10,470
Samples of milk examined (included in the foregoing),	6,256
Whole number of samples of food and drugs examined since beginning of work in 1883,	138,309
Whole number of samples of milk examined since beginning of work in 1883,	76,119
Number of prosecutions against offenders during the year,	76
Number of convictions during the year,	74
Amount of fines imposed during the year,	$2,617 98
Number of packages of antitoxin of 1,500 units each issued to cities and towns,*	33,475
Number of bacterial cultures made for the diagnosis of diphtheria in cities and towns,*	2,904
Number of examinations made for diagnosis of tuberculosis,*	928
Number of examinations of blood made for diagnosis of malarial infection,*	61
Number of examinations of blood made for the diagnosis of typhoid fever,	217
Number of notices of cases of infectious diseases received and recorded under the provisions of chapter 302, Acts of 1893,†	33,933
Number of postal-card returns of mortality for cities and towns received and recorded,† about	2,000
Number of annual reports of cities and towns received under the provisions of Acts of 1894, chapter 218,‡	94
Force employed in general work of Board at central office, State House: —	
Secretary,	1
Medical inspector,	1
Clerks,	3
Total,	5
Force employed at central office, State House, Boston, for food and drug inspection, chemists and assistants,	2
At Amherst,	1
Inspectors,	4
Total,	7

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* For the year ended March 31, 1903. † For the calendar year 1902.

‡ Cities and towns having a population of more than 5,000 in each.

Force employed at laboratory (Bussey Institute): —

Pathologist,	1
Assistants,	6
Total,	7

UNDER THE PROVISIONS OF CHAPTER 375, ACTS OF 1888.

Applications for advice from cities, towns and others: —

Relating to water supply,	54
Relating to ice supply,	6
Relating to sewerage and drainage,	19
Relating to pollution of streams,	10
Miscellaneous,	4
Total,	93

Number of samples of water examined chemically and microscopically at the laboratory, Room 502, State House,	4,328
Number of samples of sewage and effluent from sewage purification works examined chemically at the laboratory, Room 502, State House,	825
Number of samples of sewage, water and ice examined chemically and bacterially at the Lawrence Experiment Station,	1,921
Number of samples of sand examined chemically at the Lawrence Experiment Station,	183
Number of samples of sand examined mechanically at the Lawrence Experiment Station,	170
Number of samples of water and ice examined for B. coli communis in one and 100 cubic centimeters at the Lawrence Experiment Station,	3,390
Additional samples examined bacterially at the Lawrence Experiment Station,	3,883
Number of shell-fish examined for B. coli,	373
Total number of samples examined,	15,073

Force employed at central office: —*

Chief engineer,	1	
Assistant engineers,	6	
Stenographers and clerks,	3	
Messenger,	1	
	—	11

At laboratory, Room 502, State House: —

Chemist,	1	
Assistant chemists,	5	
Biologist,	1	
Stenographer,	1	
	—	8

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* Not including force employed under provisions of chapter 65 of the Resolves of 1899.

At Lawrence Experiment Station: —

Assistant chemists,	2	
Bacteriologists,	2	
Other assistants and laborers,	2	
	—	6
Total ordinary force,		25

The number of applications for advice under the provisions of the acts relating to water supply and sewerage, received since July, 1886, when these acts first went into operation, is as follows: —

1886,	8	1896,	65
1887,	22	1897,	59
1888,	28	1898,	75
1889,	38	1899,	79
1890,	23	1900,	104
1891,	53	1901,	105
1892,	56	1902,	93
1893,	51		
1894,	53	Total,	964
1895,	52		

Appropriations.

The appropriations for the year 1902, as recommended by the Board in the annual estimates made under the provisions of chapter 41 of the Acts of 1885, were as follows: —

For the general expenses of the Board,	$23,000 00
For the inspection of food and drugs,	11,500 00
For the protection of the purity of inland waters,	34,000 00
For the examination of sewer outlets,	2,500 00
Total,	$71,000 00

Expenditures.

The expenditures in 1902 under the different appropriations were as follows: —

Appropriation for general expenses of Board,	$23,000 00

General Expenditures, Sept. 30, 1901, to Sept. 30, 1902.

Salaries,	$11,157 65
Travelling expenses,	1,386 79
Stationery,	293 67
Printing,	971 48
Books, subscriptions and binding,	578 89
Advertising,	15 65
Amount carried forward,	$14,404 13

Amount brought forward,	$14,404 13	
Express charges,	245 26	
Extra services,	353 06	
Messenger,	40 10	
Postage and postal orders,	304 45	
Telephone and telegraph messages,	79 04	
Typewriter supplies,	3 75	
Special investigations,	8 83	
Sundry office supplies and incidental expenses,	555 17	
Laboratory supplies,	1,066 29	
		$17,060 08

Expenditures at Pathological Laboratory at Forest Hills.

Salaries,	$3,290 00	
Purchase of animals,	160 55	
Board of horses,	1,803 53	
Food for animals,	108 15	
Apparatus, chemicals and laboratory supplies,	924 97	
Ice,	26 15	
Postage,	2 92	
Stationery,	1 75	
Books,	5 00	
Rental of telephone and messages,	168 75	
Services of veterinary surgeon,	6 00	
Repairs on stable,	47 75	
Express charges,	16 62	
		6,562 14
Total,		$23,622 22

Under the Provisions of the Food and Drug Acts during the Year ending Sept. 30, 1902.

Appropriation,	$11,500 00
Salaries of analysts,	$4,556 66
Salaries of inspectors,	4,620 00
Travelling expenses and purchase of samples,	1,966 80
Apparatus and chemicals,	279 74
Printing,	25 16
Services (cleaning laboratory),	104 00
Express and postage,	7 08
Sundry laboratory supplies,	79 19
Books,	45 60
Extra services (stenographer),	16 00
Total,	$11,700 23

The foregoing account of expenditures for general purposes and for food and drug inspection relates to the year ended Sept. 30, 1902.

Appropriation.

For carrying out the provisions of the *act to protect the purity of inland waters*, and to require consultation with the State Board of Health regarding the establishment of systems of water supply, drainage and sewerage,	$34,000 00

Salaries, including wages of laborers at Lawrence Experiment Station,	$25,200 26
Apparatus and materials,	1,538 87
Rent of Lawrence Experiment Station,	150 00
Use of tools and office, Lawrence Experiment Station,	172 96
Travelling expenses,	2,721 83
Express charges,	1,070 11
Stationery and drawing materials,	194 04
Books, maps and blue-prints,	194 78
Services, reading gauges and collecting samples,	158 25
Telephone messages,	3 92
Special investigations,	77 00
Miscellaneous,	227 28
Reconstructing laboratory building at Lawrence,	2,290 14
Total,	$33,999 44

The foregoing statement of expenses under the act to protect the purity of inland waters refers to the calendar year 1902.

Appropriation.

For the examination of sewer outlets under the provisions of section 4 of chapter 75 of the Revised Laws,	$2,500 00

For salaries,	2,432 74
Travelling expenses,	67 25
	$2,499 99

HENRY P. WALCOTT.
HIRAM F. MILLS.
FRANK W. DRAPER.
GERARD C. TOBEY.
JAMES W. HULL.
CHARLES H. PORTER.
JULIAN A. MEAD.

WATER SUPPLY AND SEWERAGE.

ADVICE TO CITIES AND TOWNS.

ADVICE TO CITIES AND TOWNS.

Under the provisions of the Revised Laws (chapter 75, section 117) the State Board of Health is required to

> consult with and advise the authorities of cities and towns and persons having, or about to have, systems of water supply, drainage or sewerage as to the most appropriate source of water supply, and the best method of assuring its purity or as to the best method of disposing of their drainage or sewage with reference to the existing and future needs of other cities, towns or persons which may be affected thereby. It shall also consult with and advise persons engaged or intending to engage in any manufacturing or other business whose drainage or sewage may tend to pollute any inland water as to the best method of preventing such pollution, and it may conduct experiments to determine the best methods of the purification or disposal of drainage or sewage. No person shall be required to bear the expense of such consultation, advice or experiments. Cities, towns and persons shall submit to said board for its advice their proposed system of water supply or of the disposal of drainage or sewage, and all petitions to the general court for authority to introduce a system of water supply, drainage or sewerage shall be accompanied by a copy of the recommendation and advice of said board thereon.

During the year 1902 the Board has given its advice to the following cities, towns and persons who have applied for such advice under the provisions of the general act (Revised Laws, chapter 75, section 117) or under special acts relating to water supply and sewerage.

Official communications were made during the year under the provisions of acts relating to water supply as follows: —

Adams Fire District.
Ashfield.
Bedford (school committee).
Brookline (Holzer-Cabot Electric Company).
Concord (Massachusetts Reformatory).
Concord (Middlesex School).
Deerfield (South Deerfield Water Supply District) (two).
Everett.
Framingham (Dennison Manufacturing Company).
Franklin (W. J. Whiting).
Gloucester.

Greenfield (Wiley & Russell Manufacturing Company).
Hadley.
Hingham.
Holyoke (two).
Holyoke (Wm. Skinner Manufacturing Company).
Hyde Park (three).
Lawrence (two).
Leominster.
Lexington.
Lynnfield (J. F. Smith).
Manchester (two).
Milford.
Milton (three).
Milton (Oliver H. Flanders).
Montague (Miller's Falls Company).
Nantucket (Siasconset).
Natick.
Norton.
Palmer.
Plymouth.
Rockport.
Salisbury (Wm. Behan).
Scituate.
Shirley.
Southborough.
Springfield (two).
Stoughton.
Sturbridge (Fiskdale Mills).
Sunderland
Tewksbury.
Watertown (Hale House Farm).
Wellesley (Wellesley College).
Whately.
Whitman (two).
Worcester.

Official communications were made during the year under general and special acts relating to sewerage and sewage disposal, as follows: —

Bridgewater.
Hull (Fort Revere).
Lancaster.
Manchester (Essex County Club).
Maynard (American Woolen Company).
Northbridge (Whitinsville).
Plymouth (two).
Revere.
Swampscott.
Taunton.
Waltham.
Wellesley (two).
Westfield.
Wrentham.

Replies were also made during the year in answer to applications from the following authorities and individuals for advice relative to sources of ice supply: —

Boston (the Commonwealth Hygienic Ice Company).
Easthampton (Delos T. Pepin).
Franklin (board of health).
Holyoke (board of health).
Marblehead (board of health).
New Bedford (board of health).

Replies were also made in answer to applications for advice relative to the pollution of ponds, streams and other bodies of water, as follows: —

Agawam.
Charles River Dam Committee.
Cohasset (the cemetery committee).
Harwich (Wychmere Harbor).
Hudson.
Manchester.

Mattapan Improvement Association (Neponset River).
Northborough.
Waltham.
Westborough (two).
West Springfield.
Weymouth.

Rules and regulations for the sanitary protection of sources of water supply were made for the following authorities: —

Water Commissioners of Rockport.
Water Commissioners of Taunton.

The Board also approved the location of a tract of land in Grafton, Westborough and Shrewsbury, proposed for a colony of the insane in connection with the Worcester Insane Asylum.

WATER SUPPLY.

The following is the substance of the action of the Board during the past year in reply to applications for advice relating to water supply: —

ADAMS.

Nov. 6, 1902.

To the Prudential Committee of the Adams Fire District, Adams, Mass.

GENTLEMEN: — The State Board of Health received from you on September 9 an application, under the authority of section 117 of chapter 75 of the Revised Laws, giving notice of your intention to introduce a system of water supply in the town of Adams, and requesting the advice of the Board as to the most appropriate source of supply.

Some time before the application was received test wells had been sunk in the valley of the Hoosick River a short distance above Cheshire Harbor, and at your request the Board caused samples of water sent in by you from these wells to be analyzed. Soon after the application was received the Board caused the locality to be examined by its engineer, and additional samples of water to be collected for analysis after water had been flowing continuously from the wells for a considerable time. The evidence furnished by the rate of flow from these wells and by the freedom with which water could be pumped from them indicates that a large yield of water can be obtained from the ground at this place.

The water of all the samples collected was found, upon analysis, to be clear, colorless and odorless, but quite hard, and the hardness increased after a considerable quantity of water had been flowing from the wells. The Board is informed that you propose to pump water from these wells into Bassett Brook Reservoir, and supply it thence to the town after it has mingled with the water of the reservoir. The results of numerous analyses of the water of Bassett Brook, one of your present sources, show that its hardness averages about 3.2 parts per 100,000 during the dry portion of the year, and the water of the Dry Brook source is somewhat harder. Measurements of the flow of the streams show that the yield of the Bassett Brook source was less than 300,000 gallons per day and that of Dry Brook less than 100,000 gallons per day, and if the consumption of water in the town is as great as it was found to be from measurements made in 1895, — and the indications are that it has not decreased, — a very large proportion of the water used by the town in the summer season will, in the future, be obtained from the proposed new wells. Under these conditions, the hardness of the water supplied to the town in the summer season is likely to vary greatly from time to time. At times of high flow in the streams the yield of the brooks is likely to supply nearly all of the water required, while in times of very dry weather the greater portion of the supply will come from the new wells.

While sudden changes from hard to soft and again to hard water are regarded as undesirable, the data at hand are not sufficient to prove that the mixture of hard and soft water in the reservoir, and its consequent variation in hardness, will be prejudicial to health. The Board is of the opinion that the proposed arrangement will be an improvement upon the present system, and regards its adoption as permissible under the circumstances, but in making any future change in your sources of water supply the Board would advise that you procure a water of less hardness and more constant in character.

ASHFIELD.

MARCH 6, 1902.

To E. D. CHURCH, A. C. HOWES and F. H. SMITH, *Committee on Water Supply of the Town of Ashfield.*

GENTLEMEN: — The State Board of Health has considered your application for advice with reference to a proposed water supply for the village of Ashfield, to be taken from Taylor Brook, so called, located south-westerly from the village, and has caused the proposed source to be examined and a sample of its water to be analyzed. The Board has also caused examinations to be made of the waters of Creamery and Bear Swamp brooks, referred to in the report of your engineers accompanying the application.

The results of the analyses of samples of water from these sources indicate that either of them would furnish water of good quality for the supply of Ashfield. The water of Creamery Brook was of considerably better quality than that of the other two sources at the time these examinations were made, and the water of Taylor Brook, while somewhat softer and less colored than that of Bear Swamp Brook, contained a larger quantity of organic matter than the water of the latter source and a considerably larger quantity than the water of Creamery Brook. Bear Swamp Brook has a larger water-shed than either of the others, but it is probable, so far as can be judged from the information available to the Board, that a sufficient quantity of water for the supply of Ashfield could be obtained from either of the sources mentioned.

It is not possible to determine from examinations made at this season of the year the probable quality of the water of these sources at other seasons, nor has it been practicable, on account of the depth of snow, to make a sufficient examination of the water-sheds to determine which of these sources is likely to be the most desirable one for Ashfield.

The Board would advise that further examinations of the waters of each of these sources be made, and the Board will make the necessary analyses of these waters if you will collect the samples.

BEDFORD.

OCT. 2, 1902.

To the School Committee of the Town of Bedford.

GENTLEMEN: — In response to your request for an examination of the water used for the supply of the public schools of Bedford, which, the Board is informed, is taken from a well located on the premises of J. B. Prescott on North Street, near the central portion of the village, the Board has caused the well and its surroundings to be examined and a sample of the water to be analyzed.

The results of the analysis show that the water entering this well has been seriously polluted by sewage and partially purified in its passage through the ground. A water having such an analysis, with cesspools and other receptacles for sewage near at hand, cannot be regarded as a safe drinking water.

The Board would advise that a supply of water for the schools be secured from a source of known purity. The open space south-west from the school-house, as much as 200 feet from any evident source of pollution, may be a good location for a well.

The Board will assist by making analyses of water from sources you may select which, from their surroundings, give promise of safety.

BROOKLINE (HOLZER-CABOT COMPANY).

NOV. 6, 1902.

To the Holzer-Cabot Electric Company, Brookline, Mass.

GENTLEMEN: — The State Board of Health has considered your application for advice as to the quality of the drinking water of two driven wells on the premises occupied by the company between Station Street and Andem Place in Brookline, and has caused the locality to be examined by one of its engineers and samples of the water of the wells to be analyzed.

The wells are located in a densely populated part of Brookline, and the analyses show that the water has evidently at some time been greatly polluted by sewage and not completely purified in its passage through the ground to the wells.

In the opinion of the Board this water cannot be considered safe for drinking.

CONCORD (MASSACHUSETTS REFORMATORY).

JAN. 1, 1903.

To the Board of Prison Commissioners, Mr. FREDERICK G. PETTIGROVE, *Chairman.*

GENTLEMEN: — The State Board of Health received from you on Oct. 6, 1902, an application stating that under the authority of a resolve passed by the General Court of 1902 you were investigating the practicability and expediency of supplying the Massachusetts Reformatory at Concord with water from Nagog Pond, so called, in the towns of Acton and Littleton, and requesting the advice of the Board relative to the proposed source of supply. Subsequently, plans were received showing the pond, and the location and profile of a proposed pipe line from the pond to the reformatory.

In response to your application the Board has caused the pond and its surroundings to be examined by its engineer, and has considered the plans and information submitted therewith and the results of analyses of samples of the water of the pond collected at various times during the past three years.

The results of the analyses show that the water is nearly colorless and otherwise of good quality for a surface water. It has occasionally, in common with most surface waters from similar sources, a noticeable taste and odor, due probably to the presence of microscopic organisms, but the results of the microscopical examinations of this water do not show that it contains very large numbers of such organisms at any time, and it is unlikely, judging from these examinations, that the water will be noticeably affected by taste or odor except at infrequent intervals.

The pond will yield a much larger quantity of water than is necessary for the supply of the Massachusetts Reformatory, and, in the opinion of the Board, the pond would be a suitable source of supply for that institution.

The right to take a part or all of the water of this pond has already been granted to the town of Concord (chapter 201 of the Acts of 1884), and the Board is informed that the act authorizing the taking of water from the pond by that town has been accepted. It seems likely that the town of Concord will require an additional water supply in the near future, and the construction of works for the joint supply of the town and reformatory would materially lessen the cost to each if arrangements were made for an equitable division of the cost.

The water-shed of Nagog Pond contains a very small population, but there are many cottages about its shores which are occupied in the summer season, and it will be necessary, if the pond is to be used as a source of water supply, that control be obtained of the shores of the pond for a sufficient distance back from the water to prevent pollution from cottages and from those resorting to the pond for boating, fishing and bathing.

While tests have been made with a view to obtaining a supply of ground water for the institution, without favorable results, further investigations might show that it is practicable to obtain an ample quantity of ground water for the supply of the reformatory from some place in its neighborhood. A supply of good ground water would be more satisfactory, on account of its freedom at all times from taste and odor, than the water of Nagog Pond, and the cost of works for obtaining a ground-water supply might be somewhat less, on the whole, than the cost of a supply from Nagog Pond.

In view of the circumstances, it seems desirable, in the opinion of the Board, that further investigations should be made with a view to obtaining a supply of ground water, in order that the cost of such a supply may be compared with the cost of works for taking water from Nagog Pond.

Concord (Middlesex School).

Jan. 1, 1903.

To Mr. Frederick Winsor, *Head Master*, *Middlesex School*, *Concord*, *Mass.*

Dear Sir: — The State Board of Health received from you on June 28, 1901, an application for advice with reference to a system of water supply for the Middlesex School in Concord, containing the following outline of your proposed plan: —

> It is proposed to secure a supply from the ground by means of driven wells or some other method, either from the valley of Spencer Brook or the valley above Bateman's Pond.
>
> Test wells are to be driven at once to ascertain if water can be secured in either location and which location is the best.
>
> It is intended to provide a supply for the use of about 250 people, and such uses about the grounds of the school as may be desired. After the tests are made, if the result is satisfactory, plans will be prepared for your examination.

Subsequently test wells were driven at the places indicated in your application, and the Board caused an examination of the locality to be made by one of its engineers and samples of water from some of the test wells and from Bateman's Pond and Spencer Brook, two surface water sources in the neighborhood, to be analyzed. The results of the analyses were sent to your engineer.

Since that time a filter has been constructed for the purification of the water of Bateman's Pond, which is now being used as the source of water supply of the school. The water-shed of this pond is uninhabited except at the school buildings, and with all sewage from them conveyed out of the drainage area, the source is not exposed at the present time to danger of sewage pollution. Analyses of this water show that it is highly colored and contains an excessive quantity of organic matter in the summer season, but analyses of the water after passing through the filter show that its quality is greatly improved, although it has occasionally a noticeable odor when heated. In other respects the filtered water is of good quality for the purposes of a domestic water supply.

Pond waters containing large quantities of organic matter sometimes become nearly devoid of oxygen in the warmer portion of the year, and at such times are difficult to purify by filtration in the usual way. The circumstances are such, however, that very little water is required for the school in the summer as compared with the remaining portion of the year, and by operating the filter intermittently and at as low a rate as possible, good results may be secured at all times with the present works if the filter receives proper care and the quantity of water required by the school does not materially increase.

DEERFIELD (SOUTH DEERFIELD WATER SUPPLY DISTRICT).

JUNE 5, 1902.

To the Committee on Water Supply of the Village of South Deerfield.

GENTLEMEN: — The State Board of Health received from you on May 27, 1902, an application for advice with reference to a proposed water supply for the village of South Deerfield, to be taken from Roaring Brook in Whately Glen, accompanied by plans showing the proposed works. The Board has considered these plans and has caused the proposed source of supply to be examined by its engineer, and a sample of the water to be analyzed.

The results of the analysis show that the water is clear, colorless and odorless, and of good quality for the purposes of a public water supply. It does not appear that any observations have been made of the flow of this stream in the drier portion of a dry season, but, so far as can be judged from the information available, it is probable that this source will furnish, through the proposed works, a sufficient quantity of water for the village of South Deerfield at all times. If, however, it should be found that the natural yield of the source is inadequate for the supply of the village, the yield could probably be increased without special difficulty by the construction of a storage reservoir. In the opinion of the Board Roaring Brook is an appropriate source of water supply for the village of South Deerfield.

Owing to the fact that considerable numbers of people resort to Whately Glen in the summer season, it is very desirable that the intake of the South Deerfield water works be placed above the portion of the glen frequented by visitors, to avoid danger of pollution of the water; and the Board would advise that the water be taken at a point higher up stream than indicated on the plan submitted. It will also be necessary to guard against danger of pollution of the source from any of the buildings on this water-shed above the glen.

Plans have also been submitted to this Board by the town of Whately for the use of Roaring Brook as a source of public water supply. The population of the town of Whately at the present time is small, and, while the principal village is situated at a higher elevation than South Deerfield, water can be taken from Roaring Brook at a sufficient elevation so that Whately may be supplied from this source by gravity.

The Board is of the opinion that Roaring Brook is an appropriate source of water supply both for South Deerfield and Whately, and, in case the yield of this stream should at any time prove inadequate, it can be increased without special difficulty by the construction of a storage reservoir on the water-shed. There appears to be no other equally appropriate source of water supply for these towns or either of them.

Under the circumstances, the Board is of the opinion that, if the right to take a water supply from Roaring Brook shall be granted to South Deerfield, the town of Whately should not be excluded from taking a supply of water from this source if it should desire to do so.

Nov. 6, 1902.

To Messrs. J. B. Bridges, P. W. Newell, C. F. Billings, *Board of Water Commissioners of the South Deerfield Water Supply District.*

Gentlemen: — The State Board of Health received from you on Oct. 23, 1902, a communication relative to obtaining the consent of the Board to the taking of the waters of Roaring Brook and its tributaries in Deerfield and in Whately as a source of water supply for the South Deerfield Water Supply District, and for the approval of the location of a proposed dam and reservoir under the provisions of chapter 486 of the Acts of the year 1902, and soon afterward plans were received showing the proposed location of a dam and reservoir on Roaring Brook.

The Board has caused the locality to be examined by its engineer, and, having carefully considered the proposed plans, hereby consents to the taking by the South Deerfield Water Supply District, as a source of water supply, of the waters of Roaring Brook at a point shown upon a plan entitled "Map of Whately Glen and Vicinity, including Site of Proposed Reservoir for South Deerfield Water Works; scale, 100 feet to an inch, Clapp & Abercrombie, Engineers, Greenfield, Mass.," filed in the office of this Board Oct. 24, 1902, and approves the location of the dam and reservoir shown upon the said plan.

EVERETT.

DEC. 4, 1902.

To the Board of Public Works of the City of Everett.

GENTLEMEN: — The State Board of Health received from you on September 30 a request for an analysis of the water of a drinking fountain in the city of Everett, supplied from a spring located near the corner of Church and Linden streets, and in response to your request has caused the conditions about the spring to be examined and samples of the water to be analyzed. The results of the analyses show that the water is clear, colorless and odorless, and contains but little organic matter, but has evidently been at some time greatly polluted by sewage, though at the time these examinations were made the water was being well purified in its passage through the ground before entering the spring. In the state in which it was found at the time these analyses were made the water of this spring is probably safe for drinking. The danger in the use of such water for drinking is that a change in circumstances attending its pollution may result in imperfectly purified water finding its way to the spring, and, even if frequent analyses of the source should be made, such deterioration might not be detected in season to prevent harmful results from the use of the water. Water from the metropolitan works is available for the supply of this fountain, and under the circumstances the Board would advise that the use of the spring in question as a source of drinking water supply should be discontinued.

FRAMINGHAM (THE DENNISON MANUFACTURING COMPANY).

AUG. 7, 1902.

To Mr. CHARLES S. DENNISON, *Treasurer Dennison Manufacturing Company, Boston, Mass.*

DEAR SIR: — In response to your request of June 6 for a further examination of the water of the driven well at your factory at South Framingham, the Board has caused two samples of the water to be analyzed, one on June 16 and another on July 24. Comparing these results with the results of an analysis of a sample of water collected on Aug. 30, 1901, it is found that there has been a marked change in the quantity of iron present in the water, the quantity present in the sample collected in 1901 being excessive, while in the two samples recently collected the quantity of iron found was insignificant. The presence of the iron in the sample collected last year rendered the water turbid and colored, while at the present time the water is clear and colorless. In other respects the recent analyses show no material change in the quality of the water from its condition at the previous time.

As stated last year, this water is not a desirable drinking water, though it cannot be considered in its present state unsafe for drinking. If this water is to be used for drinking it should be analyzed from time to time in order that its use may be discontinued if deterioration in its quality occurs.

FRANKLIN.

MAY 1, 1902.

To WILLIAM J. WHITING, Esq., *Franklin, Mass.*

DEAR SIR: — In response to your application of April 23 for advice with reference to the quality of the water of a well located on the McCarthy Street extension in Franklin, the Board has caused the well and its surroundings to be examined and a sample of the water to be analyzed.

The results of the analysis show that the water of the well is grossly polluted by sewage, apparently derived from the sink drains and privies in its neighborhood.

The Board would advise that further use of water from this well for drinking or cooking be prevented.

GLOUCESTER.

MAY 15, 1902.

To the Water Commissioners of the City of Gloucester.

GENTLEMEN: — The State Board of Health received from you on May 3, 1902, an application requesting the advice of the Board as to the treatment of the bottom of the new Haskell's Pond basin at West Gloucester, now being constructed for the storage of water for the supply of the city of Gloucester.

You state that the bottom is covered with mud to a depth of from a few inches to several feet, and you request advice as to whether, if the sides of the reservoir should be grubbed and cleaned some 15 or 20 feet below the flow line and the bottom not disturbed, the preparation of the reservoir for the storage of water would be sufficient.

The Board has caused the bottom of the reservoir, which is now exposed and well drained, to be examined by its engineer, and has considered the information presented as to the conditions existing in this reservoir and the experience with other storage reservoirs in the State. It appears that the portions of the Haskell's Pond Reservoir which formed the bottom of the old pond, containing about 25 acres, are covered with mud or peat containing a great quantity of vegetable matter. While this matter would be covered with water at all times to a depth of several feet, even when the reservoir is drawn down to the lowest level to which it is likely to be drawn, the Board is of the opinion that, if the reservoir should be constructed leaving this portion of the bottom as it now is, the water would be very unfavorably affected thereby.

On account of the depth of this material it is not practicable to remove it, but it could be covered with sand or gravel from the adjacent slopes of the reservoir so as to prevent the water from coming in contact with it when the reservoir is filled. If this material should be covered to a depth of one foot, and the stumps removed from the slopes of the reservoir, the Board is of the opinion that the water furnished by this source would be of much better quality than if the bottom should be left in its present state, though the water might at times have a noticeable taste and odor.

GREENFIELD (WILEY & RUSSELL MANUFACTURING COMPANY).

AUG. 7, 1902.

To Mr. CHARLES P. RUSSELL, *President and Treasurer of the Wiley & Russell Manufacturing Company, Greenfield, Mass.*

DEAR SIR: — In response to your request for advice as to the quality of the water of a spring on the hillside in the rear of your factory at Greenfield, which is used for drinking purposes in the factory, the Board has caused the locality to be examined and a sample of water from the spring to be analyzed.

The results of the analysis show that the water is soft and in other respects of good quality for drinking purposes, and an examination of the surroundings of the spring does not show at the present time any condition which threatens serious pollution of the spring. In the opinion of the Board the water is safe for drinking.

HADLEY.

MARCH 6, 1902.

To JOHN J. SULLIVAN, DANIEL O'CONNELL, JR., and JOHN J. KIRKPATRICK, *Hadley, Mass.*

GENTLEMEN: — The State Board of Health received from you on February 15 an application for advice with reference to a proposed water supply for the town of Hadley, to be taken from Pratt's Pond on Hart's Brook in the south-easterly part of the town, and has caused the source and its surroundings to be examined by its engineer and samples of the water to be analyzed.

The results of the analyses show that the water at the time this examination was made was soft and had but little color, and that the quantity of organic matter present was small. An examination of the water-shed shows, however, that this brook is exposed to pollution at the present time from a house and stable near the shore of Pratt's Pond and from a State fish hatchery located at a pond on the stream a short distance above the proposed source. The danger of pollution from the farm buildings could probably be avoided by moving the barn to a new location south of the highway and providing a suitable method for the disposal of the sewage from the house. It does not appear to be practicable, however, to prevent danger of pollution from the fish hatchery as carried on at present, and the Board does not at present advise the use of Hart's Brook as a source of public water supply for Hadley.

The Board has also caused an examination to be made of the water of a tributary of Hart's Brook from the south, which enters the main stream a little over half a mile below Pratt's Pond. This tributary has a somewhat larger drainage area than Hart's Brook at Pratt's Pond, and it is probable that a somewhat larger yield of water could be obtained from it than from Pratt's Pond. The drainage area of this tributary is uninhabited, and the only danger of pollution to which the water may be exposed at present is the manuring of cultivated fields on the water-shed. The quality of the water is about the same as that of Hart's Brook, as shown by the analysis of a single sample collected recently.

Judging from the investigations thus far made, the Board is of the opinion that the tributary of Hart's Brook referred to would be a suitable source of water supply for Hadley, but would advise that further analyses of the water of this source be made. The Board will make the necessary analyses if you will collect the samples.

HINGHAM.

DEC. 20, 1902.

To the Hingham Water Company, Hingham, Mass.

GENTLEMEN: — The State Board of Health received from you on Oct. 15, 1902, an application for advice relative to increasing the quantity and improving the quality of the water supplied to Hingham and Hull which contains the following outline of your proposed plans: —

> The plan for increasing the quantity and improving the quality of the supply of the Hingham Water Company is essentially as follows: —
>
> To convey the water of Accord Brook to, and distribute it over, a portion of the valley of Fulling Mill Brook, lying to the east of Main Street, between Main Street and Fulling Mill Pond.
>
> It is proposed to distribute Accord Brook water through a series of two or more ditches, approximately parallel to the line of Fulling Mill Brook, the line of the first ditch to be about 50 feet from the brook; the second and succeeding ditches to be approximately parallel to the first ditch and at suitable distances apart, not to exceed 10 feet. The water, seeping away from the bottom of the ditches, will find its way to the brook, just as the regular rainfall does, all suspended matter will be taken out at the bottom of the ditch, and the slow filtration will remove the color and all impurities, so that the water delivered will be of as good quality as that now running in the brook.
>
> Test pits dug at various points on the area which it is proposed to use show coarse sand and gravel, which seem to be eminently adapted to the filtration of water.
>
> The coarse material will without doubt pass a large amount of water, while the long distance which the water has to traverse before reaching the collecting system will ensure a more complete purification than could be obtained by artificial filtration beds.

If it should be found that the ditches laid out at first were insufficient, there is ample area to be obtained for extending the system of irrigating ditches.

It is proposed to use Fulling Mill Brook and its tributaries as a collecting system without a great deal of further preparation. In a few words, the plan is simply to increase the present flow of Fulling Mill Brook by distributing on its water-shed a sufficient amount of water in addition to the regular rainfall.

The indications are that in the near future Accord Pond will have to be used almost exclusively as a storage reservoir, to be drawn from only at the time when the demand upon the works is greatest, namely, from the first of July until about the middle of September. If the proposed scheme of filtration operates as expected, a sufficient supply can be obtained for the demand between the middle of September and the middle of June or first of July from Fulling Mill Brook, reinforced by water from Accord Brook.

It is proposed to so arrange the conduits leading to the irrigating ditches that they may be supplied from either Accord Pond, Accord Brook, or both, as the demands of the system require. There will also be a connection from Accord Pond to the pumping plant.

To take care of the increased supply and to better the service, particularly for fire, it is proposed to install a new pumping station in the vicinity of Fulling Mill Pond, to construct either a stand-pipe or a reservoir, at such height as to give an increased head in the mains. Contracts have already been made for increasing the height of the present stand-pipe at Strawberry Hill.

New mains are to be laid to enable the system to meet the increased demands already placed upon it, and they will be large enough to supply all water required for a number of years to come.

We hand you herewith blue print of contour map of Fulling Mill Pond, Fulling Mill Brook and a part of its water-shed, in which the proposed system of filtration is to be installed.

Also hand you report of results of test pits dug on this water-shed at the points indicated on the plan. These results show the existence of coarse sand and gravel, well adapted for purposes of filtration.

In response to your application the Board has caused the locality to be examined by its engineer, and has carefully considered the plans submitted and the other information available as to the capacity of your present sources and the quality of their waters. The water of Accord Pond has frequently been very objectionable to consumers on account of a disagreeable taste and odor, caused by the presence of microscopic organisms of various kinds. The quality of the water supplied from the Fulling Mill Pond source was also very objectionable in earlier years, but since works were built for taking water from the brook, which is the main feeder of the pond, and from a filter gallery on its easterly shore, water of much better quality than formerly has been obtained from this source.

Accord Brook, the proposed source of additional supply, will, if used in connection with the present sources, materially increase the quantity of water available for the supply of Hingham and Hull. By using this source in connection with Fulling Mill Pond the draft upon Accord Pond in the winter and spring can be greatly reduced, and most of the water of this source kept for use in the drier portion of the year.

The water of Accord Brook, on account of its high color and the large quantity of organic matter which it contains during much of the year, would be very objectionable for domestic uses if supplied directly to consumers. This source, however, appears to be the most available of the sources which might be used for an additional water supply for Hingham if its waters can be rendered satisfactory.

The plan now proposed for conveying this water to the neighborhood of Fulling Mill Pond, and purifying it there by filtration through the extensive natural beds of sand and gravel found in this region, appears to be the best that it is practicable to adopt, and by this plan it is likely that water of good quality for all the purposes of a public water supply can be obtained at reasonable expense. The proposed plan also makes provision for conveying the water of Accord Pond to the same locality and purifying it by filtration at times when the quality of the water is objectionable, and there appears to be no better way of rendering the water of this source satisfactory to consumers.

The plan suggested by you of distributing the water in trenches parallel to the main feeder of Fulling Mill Pond, and allowing it to filter through the ground to the stream, could probably be made to give satisfactory results, and the cost of the trenches would be small. It would not be a difficult matter, however, to prepare filter-beds by levelling off some of the lands south or west of Fulling Mill Pond, which are well situated for the purpose, upon which the waters of Accord Brook or Accord Pond could be delivered by gravity. The cost of prepared areas would not very materially increase the cost of the works, and by the use of such areas it would be practicable to regulate the rates of filtration more definitely, and observe and control the results more closely, than would be the case if trenches should be used. The Board would advise that an area of this kind be prepared in the beginning and operated for a time, and the results carefully observed for use in further development of the filtration works. At the same time trenches might be operated as proposed and similar observations made upon that method of purifying the water. It is important that the filters for the purification of water be operated intermittently, and the surface of the beds allowed to become exposed to the air for a considerable time as often as once in twenty-four hours. The filter-galleries, reservoirs and other works for collecting filtered water near Fulling Mill Pond should be placed at a sufficiently low level to prevent danger that any of the water may escape into the pond.

It is very important, in the opinion of the Board, that the filtered water, whether from trenches or filter-beds, be collected and stored in covered galleries or reservoirs, since otherwise it is liable to deteriorate and become objectionable on account of the presence of organisms which are apt to appear in great numbers in ground waters exposed to light.

The plan in general is, in the opinion of the Board, an appropriate and satisfactory one for improving and increasing the water supply of Hingham and Hull, and, when further details of the plan of filtering the water have been prepared, the Board will give you further advice if you so request. In preparing such details of filtration areas it is desirable that the character of the soil and depth of the ground water be determined by means of test pits.

HOLYOKE.

MAY 15, 1902.

To the Water Commissioners of the City of Holyoke.

GENTLEMEN: — In response to your application, received May 8, requesting an examination of the water of Ashley Pond to determine the cause of the present very unpleasant odor, the Board has caused the pond and its surroundings to be examined, and samples of water collected from many places in the pond to be examined microscopically.

The results of the examination show that *Uroglena*, an organism which has been known to cause very disagreeable tastes and odors in other ponds and reservoirs, was present in large numbers in the water of Wright Pond at the time this examination was made, and the disagreeable taste and odor complained of by those to whom this water is supplied are doubtless caused by the presence of this organism.

The Board is unable to advise you as to any practicable method of preventing the appearance and growth of such organisms in ponds, but, since it appears probable that the organism is not always present in both of the ponds at the same time, it is desirable to provide some method by which water may be drawn directly from Ashley Pond if found desirable, and the water of Wright Pond kept from mingling with it. It is also desirable that provision be made so that water may be drawn directly from the Manhan River for the supply of the city when the quality of the water of the ponds is objectionable.

NOV. 6, 1902.

To the Board of Water Commissioners of the City of Holyoke, MR. A. E. PICKUP, *Registrar.*

GENTLEMEN: — The State Board of Health received from you in June last the following communication, requesting information as to the advisability of allowing fishing in the ponds and reservoirs of the Holyoke water works: —

> I am directed by the secretary of the board of water commissioners to request your opinion as to whether or not it is advisable to allow fishing from boats on the ponds or reservoirs of the city's water supply three days a week, under the

supervision of the water department; also if it is advisable to allow fishing from the shores of same.

Would also request information as to what the results have been from allowing fishing from boats at South Framingham reservoir, and if it is the custom throughout the State to allow such fishing on domestic water supplies.

Can you inform me whether there are any fish we can get to put in the reservoirs that will, through time, drive out the so-called mud fish?

The city of Holyoke has wisely secured control of the water-sheds of the main reservoirs from which its water supply is drawn, and has removed all possible sources of sewage pollution therefrom. If unrestricted fishing shall now be allowed in the reservoirs, and considerable numbers of people resort to the reservoirs for this purpose, there is a liability that the water supply may be polluted and serious injury result to the health of some of those who use the water for drinking. It is possible, however, that a limited number of persons might be allowed to fish in the reservoirs, either from boats or the shore, under proper restrictions, and with suitable inspection under the direction of the water department, without danger of harmful results to the health of the people of the city. It would be advisable, however, even then, that fishing should not be allowed in the neighborhood of the place or places from which water is drawn for the supply of the city.

Whether the removal of fish from the reservoirs would have an effect on the quality of the water the Board is unable to advise you definitely, but so far as now known the removal of considerable numbers of the larger fish found in such reservoirs is not likely to have an unfavorable effect upon the quality of the water.

Regarding the custom throughout the State as to allowing fishing in domestic water supplies, inquiry by the Board shows that of 40 places from which information has been obtained, unrestricted fishing is permitted in 18, while in the remaining 22 places there are restrictions; of the 22 places in which fishing is restricted, it appears that the restrictions in 4 places are made and enforced by the fish and game commission, the ponds having been stocked by that commission; in 7 of the remaining 18 places no fishing whatever is allowed, while in 2 places fishing is not allowed in some of the reservoirs but is permitted in others; at 1 place no fishing is allowed within 500 feet of the point from which water is drawn, and in 4 other places where there are restrictions fishing is permitted at all times. Of the 22 places in which fishing is restricted, a written permit to fish is required in 5 places.

In reply to your last question, it is not likely, so far as the Board is now informed, that there is any kind of fish which, if placed in your reservoirs, will drive out the perch and sun-fish, which you designate as mud fish.

HOLYOKE (SKINNER MANUFACTURING COMPANY).

JULY 3, 1902.

To Mr. JOSEPH A. SKINNER, *Treasurer of William Skinner Manufacturing Company, Holyoke, Mass.*

DEAR SIR: — The State Board of Health received from you on May 3 a communication requesting advice as to the use of the water from a certain well at your factory in Holyoke for supplying drinking water to about 300 employees in the factory. Subsequently you requested advice as to the quality of the water of another well, to be used by 600 employees in another factory.

The Board has caused the wells and their surroundings to be examined by one of its engineers, and several samples of water from each of the wells to be analyzed. The source of supply in each case is a tubular well 6 inches in diameter, one well, which is 269 feet in depth, being located near the corner of Appleton and Bigelow streets, and the other, 321 feet in depth, at the corner of Appleton and Bond streets, in the central portion of the city. The results of the analyses of the water of the well near Bond Street show that it is clear, colorless and odorless, but it is a hard water, and the hardness increased materially during the course of the examination, being, in the last sample collected, about four times as great as the average hardness of the water of the principal sources of supply of the city of Holyoke. The water of the Bigelow Street well was of somewhat poorer quality than the water of the Bond Street well and was harder. In this case, also, the hardness of the water increased materially during the course of the examinations made by the Board.

These analyses show that the waters of these wells are safe for drinking at the present time, but the great hardness of the waters is objectionable, and, in view of the fact that the wells are located in a densely built-up portion of the city, where the ground water is exposed to pollution, the Board cannot advise that the water will be permanently suitable for drinking. This can only be determined by analysis after the water has been continuously drawn from the wells for a considerable period. After this has been done the Board will, upon notification, make further analyses and inform you of the result.

HYDE PARK.

MARCH 6, 1902.

To the Hyde Park Water Company, Hyde Park, Mass.

GENTLEMEN: — The State Board of Health has to-day sent a communication to the boards of health of Milton and Hyde Park relative to the quality of the water supplied to those towns.

A copy of this communication is enclosed herewith.

MARCH 6, 1902.

To the Board of Health of the Town of Hyde Park.

GENTLEMEN: — In response to your application of February 19 for advice as to the quality of the water of four wells used as sources of water supply for domestic purposes, the Board has caused the wells and their surroundings to be examined and samples of their water to be analyzed.

The wells examined were: —

1. A well in the yard in front of house No. 22 Easton Avenue.
2. A well in house No. 23 Easton Avenue.
3. A well in house No. 14 Easton Avenue.
4. A well in the yard of the house at the corner of Easton Avenue and Bridge Street.

The results of the analyses show that the water of all of these wells is quite hard, and has evidently been at some time greatly polluted by sewage and not thoroughly purified in its passage through the ground to the wells.

In the opinion of the Board the water of all of these wells is unsafe for drinking.

MARCH 6, 1902.

To the Board of Health of the Town of Hyde Park.

GENTLEMEN: — In response to a recent application from the town of Milton for advice as to the condition of the water supplied to that town by the Hyde Park Water Company, aside from its liability to cause lead poisoning, the Board has this day sent to the board of health of Milton a statement of the results of its investigations as to the quality of the water.

Since this water is supplied to Hyde Park as well as to Milton, and the condition of the water is of equal interest to the inhabitants of Hyde Park, a copy of the communication to the town of Milton is sent you herewith.

LAWRENCE.

MAY 15, 1902.

To the Lawrence Water Board, Lawrence, Mass.

GENTLEMEN: — The State Board of Health received from you on April 7, 1902, an application for advice relative to dividing the Lawrence city filter into three beds of equal area, in which you state that your board concludes that the time has arrived when this change is an imperative necessity on account of the very close margin between the amount that can be filtered under the present system and the consumption of water in the city. It is also expected that the dividing walls will decrease the cost of operating the filter and of pumping. Subsequently, plans and specifications were received, showing the proposed location and method of construction of the dividing walls.

The Board has considered your application and the plans submitted therewith and the careful and complete records which have been kept relating to the management and operation of the filter and the quantity of water used by the city.

The average daily consumption of water by the city was less in 1901 than in the three previous years, and less than in the year when the filter was constructed, but in the first four months of the present year the records of the quantity of water used have shown a marked increase over previous years. The city of Lawrence is increasing rapidly in population, and the causes which have operated to prevent a material increase in the use of water during the past ten years are unlikely to continue to prevent an increase in the quantity of water used by the city in the future. A rapid increase in quantity used, keeping pace fully with the increase in population, must now be provided for.

It appears that for a period of many days during the past winter the consumption of water in the city was greater than the capacity of the filter, and that the quantity of water stored in the reservoir was for several days nearly exhausted. It is evident that the capacity of the filter under present conditions is not sufficient for the present requirements of the city at times in the winter season.

If the filter should be divided into three sections as proposed there appear to be some advantages that would result in the management of the filter; but these advantages would probably all be secured by covering the filter. Any increase in capacity expected to result from dividing the filter would not, in the opinion of the Board, be of material value; but your experience of last winter points directly to the necessity of your proceeding immediately to have it covered, thus relieving it of the obstructions of ice and snow and of freezing weather, and enabling you to keep it free from obstructing sediment upon the surface, and to maintain, as near as practicable, the condition existing during the summer. In the opinion of the Board it is essential that this be done immediately, to secure a sufficient supply of water through the coming winter.

When the present filter was constructed it was not expected that it would serve the city without an addition when the population of the city became as great as at present, but you have been unusually successful in keeping down the consumption of water by your meter system and by the good work that has been put into the pipe system to prevent leaks. Even under these conditions the Board is of the opinion that it is not safe to expect that exigencies may not occur, like a succession of fires in winter requiring an unusual draft of water, which will overtax the present filter and exhaust the reserve in the reservoir by the time a new filter can be constructed.

The Board would therefore advise that you proceed at once to make surveys, prepare plans and construct another filter west of the present filter, as proposed in the original plan. The new filter should have an area of as much as two acres and consist of two separate beds, with provision for further extension up the river in the future. It is not probable that the new filter can be completed the present year, but the old filter, if covered, will alone serve through the coming winter until the new filter can be completed.

When you have prepared plans for covering the present filter or for constructing the new filter the Board will, upon application, advise you concerning them.

Aug. 7, 1902.

To the Mayor and Aldermen and Council of the City of Lawrence, Mass.

Gentlemen: — In response to a request for advice from the Lawrence water board in regard to building two dividing walls in the Lawrence filter, the State Board of Health, under date of May 15, 1902, advised as follows, viz.: —

> It appears that for a period of many days during the past winter the consumption of water in the city was greater than the capacity of the filter, and that the quantity of water stored in the reservoir was for several days nearly exhausted. It is evident that the capacity of the filter under present conditions is not sufficient for the present requirements of the city at times in the winter season.
>
> If the filter should be divided into three sections as proposed there appear to be some advantages that would result in the management of the filter; but these advantages would probably all be secured by covering the filter. Any increase in capacity expected to result from dividing the filter would not, in the opinion of the Board, be of material value; but your experience of last winter points directly to the necessity of your proceeding immediately to have it covered, thus relieving it of the obstructions of ice and snow and of freezing weather, and enabling you to keep it free from obstructing sediment upon the surface, and to maintain, as near as practicable, the condition existing during the summer. In the opinion of the Board it is essential that this be done immediately, to secure a sufficient supply of water through the coming winter.

This Board now learns with regret that upon request of the water board the city government authorized it to build the dividing walls, but took no action that will protect the citizens from drinking the polluted water of the river next winter.

The proposition to build the walls was urged by the water board upon the ground that the pumps could be kept running and drawing from two-thirds of the filter while one-third was being scraped.

By the records received from the water board it appears that during the cold months of January and February of last winter, when the filter could not supply the quantity of water drawn by the city, the quantity of water pumped on all of the days when the beds were scraped was less by 3.4 per cent. of the supply of the two months than if those days had supplied the average amount.

During these two months the actual times when pumping was stopped, on the days when beds were scraped, was twenty-eight hours and forty minutes, which is 2 per cent. of the time of these two months; but during the time of scraping the smaller pump was run a larger proportion of the time than ordinary, so that the total stopping was the equivalent of forty-one hours and eleven minutes of the large or low-service pumps at their ordinary capacity and ordinary running.

If the two proposed dividing walls had been in at that time the pumping could have been continued at two-thirds the ordinary capacity of the low-service pumps for forty-one hours and eleven minutes more time in the two months than it was continued, or the equivalent of running the ordinary capacity twenty-seven hours and twenty-seven minutes longer in the fifty-nine days of fourteen hundred and sixteen hours, or 2 per cent. more time for pumping would have been gained; but the two dividing walls will displace about 1 per cent. of the sand of the filter and decrease the filtering capacity to this extent, hence, if the walls had been in last winter, with the same intelligence that then managed the filter, only 1 per cent. more water could have been pumped than was pumped.

The actual amount of water supplied by the filter and pumped to the reservoir last February was, according to the records received from the water board, 5 per cent. less than the quantity of water drawn from the reservoir by the city. By the last census it appeared that the population of the city was increasing 3.6 per cent. per year, and the records given us by the water board show the increase in water pumped the last twelve months has been 8 per cent. over the previous twelve months.

With this data you will see that no dependence in preserving the health and lives of the citizens is to be placed upon an expedient having so insignificant an advantage.

It is not necessary to again point out the great destruction to health and life that will result if the unfiltered water is pumped into your reservoir, which has been so clearly presented to you by our representative in person; but for the preservation of the health and the lives of your citizens this Board earnestly repeats its advice that the filter be immediately covered.

Leominster.

Nov. 6, 1902.

To the Leominster Water Board, Mr. W. Howard Chase, *Chairman.*

Gentlemen: — The State Board of Health received from you on June 9 last a communication stating that complaint was being made regarding the quality of the water supplied to the town from Fall Brook Reservoir, and requesting the Board to investigate the cause of the trouble and advise you concerning it.

In response to this request the Board has caused the source to be examined during the past summer and samples of the water collected from various parts of the reservoir to be analyzed, and has examined the results of numerous analyses of the water of this source made since the reservoir was completed in the latter part of 1896.

An examination of the results of all of the chemical analyses made since the reservoir was completed shows that the color of the water and the quantity of organic and mineral matter present were greatest in the first year after the completion of the reservoir, much less in the second year than in the first year, and there was a somewhat further decrease in the third year. Since that time the color and the quantity of organic matter have remained nearly constant, and no marked increase has been noted thus far during the present year. The results of microscopical analyses of the water do not show that a materially greater number of organisms was present during the past winter and spring, when the quality of the water was objectionable, than in previous years. They show, however, that the water contains at times considerable numbers of certain microscopic organisms, which have been known to cause disagreeable tastes and odors in the water of ponds and reservoirs. The disagreeable taste and odor complained of during the past winter and spring were probably due in the early part of the winter to the presence of the organism *Dinobryon*, during March and April to the organism *Uroglena*, and in May to the organism *Anabœna.* All of the organisms mentioned are likely to impart to water a disagreeable taste and odor.

The cause of the presence of such organisms in water is not known, but they are present often in great abundance at all seasons of the year in the waters of some ponds and reservoirs, especially in reservoirs from which the soil and organic matter were not removed before flowing. Fall Brook Reservoir, however, was thoroughly prepared for the storage of water by the removal of soil and organic matter from its sides and bottom, and by covering with sand and gravel the deposit of peaty soil found in a portion of the bottom, which was so deep that it was not feasible to remove it.

The reservoir has not been drawn off since it was first filled, so that a thorough examination of the bottom of the reservoir, in order to ascertain whether the gravel filling remains in place, has not been practicable; but numerous careful soundings of the bottom in the area covered with gravel, which is definitely outlined upon a plan on file at this office, show that the gravel covering is still in place, at least in all those portions of this area examined, and there is no evidence from this examination that it had settled into the peaty matter or that the latter comes in contact with the water at any place. Samples of water collected from the bottom of the reservoir in places where the peat had been covered with gravel were found by analysis to be of about the same quality as the samples collected at the surface in various parts of the pond.

The quantity of organic matter present in the water of this reservoir, as shown by the albuminoid ammonia, has never been excessive, and the quality of the supply has been — except during short periods — satisfactory since the reservoir was first used. Troubles like that which occurred during the past winter and spring are likely to continue to occur at times in the future, but it is unlikely, so far as can be judged from present information, that such troubles will be serious or long continued, and the use of drinking water containing such organisms is not known to be injurious to health.

LEXINGTON.

JULY 3, 1902.

To the Committee on Water Supply of the Town of Lexington, A. E. SCOTT, *Chairman.*

GENTLEMEN: — The State Board of Health has considered your application for advice with reference to a proposed additional water supply for the town of Lexington, in which you give the following outline of your proposed plan: —

> It is proposed to obtain an additional supply of water from 10 to 15 wells driven in the meadow between our present wells Nos. 1 and 2 and No. 6, pumping these wells when the water is required into our new receiving basin.
>
> It is believed that the water obtained from this source will enable us to stop the use of wells Nos. 1 and 2 during the winter and spring months, when the water of those wells is discolored.
>
> We are not expecting great results during a dry season.

You also submit the results of a test made by pumping from test wells at the place indicated in your application, from which it appears that water was pumped from 14 wells, having an average depth of about 27 feet, at a rate of 125,000 gallons per day, from March 25 to April 7, during which period the ground water in the vicinity of the test wells was lowered about 24 feet.

The Board has caused the locality of the new wells to be examined by its engineer, has caused samples of water collected from the test wells from time to time, during the pumping test referred to, to be analyzed, and has considered the information available as to the yield of your present sources of supply and the quality of their waters. Water collected from the tubular test wells during the pumping test was clear, nearly colorless and odorless and otherwise of excellent quality for the purposes of a public water supply. On account of the deep layer of peat upon the surface of the ground in which these wells are driven, and the comparatively small depth of the wells, there is danger that this water would deteriorate and become affected by an excess of iron and organic matter, which would render it objectionable for some domestic uses, if these wells should be used continuously as sources of water supply for Lexington.

The quantity of water drawn from the wells during the pumping test, which amounted to about 125,000 gallons per day, probably represents the maximum amount of water which it is possible to obtain from them, since this test was made in the most favorable portion of the year for obtaining a large yield of ground water, and at a time when the rainfall was much in excess of the normal. Even under these conditions the water in the ground about the wells was lowered so greatly that it is doubtful whether the rate of pumping could have been maintained for any considerable time longer. Judging from the information submitted to the Board relative to the pumping test, and experience with other similar sources, the quantity of water obtainable from these wells in the drier portion of the year would be but a small proportion of the yield at the time the test was made, and, as you anticipate, would not be a material addition to the quantity of water that your present sources will yield; and, while the use of these wells may enable you to avoid the use of water from some of the other sources during the wetter portion of the year, the water of these objectionable sources will have to be used in the drier portion, unless an adequate additional water supply is obtained. The water of several of your present sources of supply is objectionable on account of color, taste or odor, and the water of one of these sources (Vine Brook) cannot safely be used for drinking unless properly filtered. The present complicated system of works is costly to maintain, and the experience of the past two years has shown that the present sources are inadequate for the supply of the town in the drier portion of the year.

It is unlikely, in the opinion of the Board, that a sufficient quantity of good water for the supply of Lexington can be obtained in the valley of Vine Brook by any further development of the sources in this valley.

LYNNFIELD (J. F. SMITH).

AUG. 7, 1902.

Mr. J. F. SMITH, *Lynnfield, Mass.*

DEAR SIR: — In response to your application of July 2 for advice as to the quality of the water of a spring situated near Lowell Street, Lynnfield Centre, from which you propose to sell water for drinking, the Board has caused the spring and its surroundings to be examined and a sample of the water to be analyzed.

The results of the analysis show that the water is of good quality for drinking, and an examination of the surroundings shows that there are no buildings on the water-shed of the spring which would be liable to affect the quality of its water.

In the opinion of the Board this spring, under present conditions, is a safe source of drinking water supply.

MANCHESTER.

JULY 3, 1902.

To the Board of Health of the Town of Manchester, Mr. WILLIAM H. ALLEN, *Secretary.*

GENTLEMEN: — The State Board of Health, in response to your request of May 3, has caused an examination to be made of the quality of the water of the groups of wells from which the Manchester water supply is obtained, and has caused an examination of the conditions about the wells to be made by one of its engineers.

The water of all the sources has at some time been polluted by sewage, but subsequently very thoroughly purified in its passage through the ground before reaching the wells, and the recent analyses of the water do not show any material change in the quality of the water from previous years. The Board sees no reason for thinking that the water of any of the sources in its present state is liable to be in any way injurious to health if used for drinking. It is very important, however, to prevent the deposit of sewage near the wells, and, so far as possible, upon or in the ground at any place from which the ground water drains toward the wells, and it is specially important to prevent the pollution of Saw Mill Brook above the wells, since it is probable that a considerable quantity of water enters the wells by filtration from this brook.

In the course of the recent investigation it was found that sewage from the cesspools of the Essex County Club was overflowing into the stream passing near the wells. The Board would advise that provision be made for the purification of this sewage or its discharge at some suitable place where it will not pollute the waters of this brook.

Dec. 4, 1902.

To the Board of Water Commissioners of the Town of Manchester, Mr. Nathan P. Meldram, *Chairman*.

Gentlemen: — The State Board of Health received from you on October 6 an application for advice relative to obtaining an additional water supply for the town from tubular wells in that part of the town known as Samuel Allen's meadow, on the easterly side of the county road to Essex, and also from wells on the easterly side of Essex Street. The tests thus far made have consisted in sinking test wells in the valley of Saw Mill Brook on both sides of the road from Manchester to Essex, about one and one-half miles north of the village of Manchester, and the Board has caused this region to be examined by one of its engineers and samples of the water from several of the test wells to be analyzed.

The wells are located in meadow and swamp lands which are at times overflowed with water, and the soil found in sinking the test wells consisted of a layer of peat or muck at the surface from 2 to 4 feet in depth, beneath which a stratum of clay was found in all of the wells, ranging from 20 to 50 feet in thickness. Beneath the clay the wells enter coarse sand and gravel. Water flowed naturally from most of the wells up to a level of about 18 inches above the meadow, and could be drawn from them freely when pumping with a hand pump, and the indications are that a quantity of water could be obtained from the ground in this region which would form a material addition to the water supply of Manchester.

The results of analyses of samples of water collected from six of the wells show that it is turbid and quite highly colored, and contains so large a quantity of iron that it would be objectionable for many of the purposes of a public water supply.

In view of the circumstances, the Board does not advise the town to take an additional water supply from the ground in this region, but would advise that further tests be made in some other locality, with the view to obtaining an adequate additional supply of good water free from an excessive quantity of iron.

MILFORD.

JUNE 5, 1902.

To the Milford Water Company, Milford, Mass.

GENTLEMEN: — The State Board of Health received from you on May 7, 1902, an application for advice with reference to the extension and improvement of the water supply of Milford and Hopedale, accompanied by plans of proposed new works for filtering the water of Charles River.

The plans submitted provide for constructing at the site of present open filter No. 1 near the pumping station two covered filters, having a combined area of .261 of an acre, and another open filter to be constructed by underdraining the material found near well No. 3, which you have found suitable for the purpose. The latter filter is to be constructed for temporary use during the building of the covered masonry filter, but will be retained for use in the future when necessary.

The filtering material in the proposed new covered filters is to consist of sand 3 feet 3 inches in depth, having an effective size of from .27 to .35 of a millimeter, which is to be thoroughly underdrained. The effluent from these filters and from the open filters is to be discharged into well No. 1, which is to be provided with a tight bottom to prevent the entrance of ground water. It is understood that the connection between well No. 1 and the conduit leading to well No. 2 will be so arranged that water will be drawn from the conduit or well No. 2 only when the supply of filtered water is less than the quantity required for the supply of the towns. Well No. 3 will remain as at present, being connected with the pumping station by a separate pipe.

The Board has caused the locality to be examined by its engineer, and has carefully considered the plans and information submitted therewith and the conditions affecting the water supply of Milford and Hopedale.

The water-shed of the Charles River above your present works does not contain a large population, but the water is affected by organic matter in swamps on the water-shed and by storage in the reservoirs, which evidently contain considerable quantities of such matter. The quality of this water has evidently been much improved by filtration through the present filters, and the proposed filters, if constructed in a thorough manner and properly operated, are likely to render this water satisfactory for all domestic purposes.

In connection with an investigation made by this Board relative to the action of water used for the supply of Milford and Hopedale upon lead pipes in the latter part of 1899 the Board caused the wells and filters from which the supply was drawn to be examined, and, as a result, it was found that the waters of Charles River and of the filters contained so small a quantity of carbonic acid that these waters would not be likely to attack lead pipes to such a degree as to cause lead poisoning. Analyses of the water of well No. 1, however, showed that it contained a very large quantity of carbonic acid, which would undoubtedly cause it to take up large quantities of lead in passing through lead pipes, and the water of well No. 2, though containing less carbonic acid than well No. 1, still contained a much larger quantity than was found in the river water or the water from the filters, and the Board advised that you discontinue the use of the water of wells Nos. 1 and 2.

It appears that by the present plan it is proposed to discontinue the use of water from well No. 1, but to continue the use of water from well No. 2. In the opinion of the Board it is desirable to avoid the use of any water from this well, even though the quantity supplied may be small as compared with the total quantity used by the towns.

The plan, as a whole, with the modification relative to well No. 2, is, in the opinion of the Board, a suitable one for improving the water supply of Milford and Hopedale.

MILTON.

JAN. 23, 1902.

To the Board of Health of the Town of Milton, WALTER C. KITE, M.D., *Secretary.*

GENTLEMEN: — In response to your request of Dec. 11, 1901, for an investigation of reported cases of lead poisoning in Milton, the Board has caused the cases referred to to be visited by its medical inspector, and samples of the water from the service pipes in the houses where the cases were found, and from other parts of the water system, to be analyzed. The results of the examinations thus far made show seventeen well-marked cases of lead poisoning, some of them very severe.

The results of chemical analyses of the water in the houses in which cases of lead poisoning were found, as well as in many houses in different parts of the town supplied through lead pipes, show that it contains an excessive quantity of lead, which is evidently taken up by the water in passing through the lead service pipes through which water from the street mains is supplied to and distributed about the houses. Examinations of the water supplied to Milton show that it contains an excess of carbonic acid, which, acting upon the lead of the pipes, produces the poisonous carbonate of lead, — a poison which slowly accumulates in the human body, with very serious results.

The investigations of the Board show that the water now supplied to Milton cannot be conveyed into and distributed about the houses through lead pipes without jeopardy to those by whom the water may be used, and that it is necessary, in order to preserve them from serious injury to health, either to replace all lead pipes by pipes from which the water will not extract poison, such as lead pipes lined with tin or iron pipes lined with tin or with cement, or else to obtain from another source water which will not act upon the lead. One course or the other should be pursued without delay.

The water of the metropolitan supply has been found not to act upon lead to an extent that is found to be injurious.

March 6, 1902.

To the Board of Health of the Town of Milton, Walter C. Kite, M.D., *Secretary.*

Gentlemen: — The State Board of Health has considered your request for a statement as to the condition of the water supplied to Milton aside from its liability to absorb lead, and has examined the results of chemical analyses of the water of both of the sources of water supply of the Hyde Park Water Company from which the water supplied to Milton is taken.

The water supply of the Hyde Park Water Company is taken from two sources, the first being a group of tubular wells located near the right or easterly bank of the Neponset River, just above the thickly settled portion of Hyde Park. This source has been in use since 1885. The second source is a group of tubular wells on the southerly side of Mother Brook, close to the boundary line between Hyde Park and Dedham.

Recent analyses of the water of each of these sources and of the water at the point where it enters the town of Milton show that a very large proportion of the water being supplied to Milton at the time these examinations were made was derived from the wells near the Neponset River. The results of many analyses of this water, made since 1887, show that its quality has greatly deteriorated in later years, and a comparison of the analyses with analyses of the water of other ground-water supplies in the State shows that during the past year the water of these wells has been of poorer quality on the whole than that of any other public water supply in the State drawn from the ground. It is evident, from an examination of the region about the wells and from a comparison of the results of the chemical analyses of the water with analyses of the water of the river, that a large portion of the water which enters the wells is derived from the Neponset River, a grossly polluted stream, and is very imperfectly purified in its passage through the ground. Considering the circumstances, the water of these wells must, in the opinion of the Board, be regarded as unsafe for drinking.

The remainder of the water supplied to Hyde Park and Milton is drawn from a group of tubular wells near Mother Brook, in the neighborhood of the boundary line between Hyde Park and Dedham. At the present time this water is probably safe for drinking, but the mixture of this water with the water from the wells near the Neponset River which has been supplied to Milton is not, in the opinion of this Board, safe for drinking.

March 6, 1902.

To the Milton Water Company, Milton, Mass.

Gentlemen: — A communication has to-day been sent by the State Board of Health to the boards of health of Hyde Park and Milton relative to the quality of the water supplied from the works of the Hyde Park Water Company to the town of Hyde Park and, until recently, to the town of Milton.

A copy of this communication is enclosed herewith.

Milton (Oliver H. Flanders).

March 6, 1902.

To Oliver H. Flanders, *Milton, Mass.*

Sir: — The State Board of Health has considered your application for advice with reference to a source of water supply in the village of East Milton in the town of Milton, and has caused the source and its surroundings to be examined and a sample of the water to be analyzed.

The results of the analysis show that the water in its present state is of good quality for the purposes of a public water supply, and the source does not appear at the present time to be exposed to serious danger of pollution. No definite information is available as to the probable yield of the source from which the present supply is obtained, but, so far as can be judged from its location and the character of the soil and topography of the region about the well, it is very doubtful whether it will yield at all times a sufficient quantity of water for any considerable number of people in excess of the seventeen families which are now supplied.

If houses should hereafter be constructed in the immediate neighborhood of the well, or upon the slope above it, there is danger that the quality of the water will deteriorate.

Montague (Miller's Falls Company).

Feb. 6, 1902.

To the Miller's Falls Company, Miller's Falls, Mass.

Gentlemen: — The State Board of Health received from you on Jan. 11, 1902, an application for advice with reference to the quality of the water of a new tubular well located at your works at Miller's Falls, the water of which you state you desire to use for drinking purposes, and has caused the well and its surroundings to be examined and a sample of the water to be analyzed. The results of the analysis show that the water is soft, nearly colorless and odorless, and, in the opinion of the Board, this water is, in its present state, of excellent quality for drinking purposes.

An examination has also been made of another well, about 31 feet deep, from which the employees of the factory and many families are supplied with water for drinking purposes. This water shows evidence of having been at some time slightly polluted by sewage and subsequently thoroughly purified in its passage through the ground, and is, in its present state, safe for drinking; but the quality of the water is not as good as that of the water of the new well.

The Board would advise that another analysis be made of the water of each of these wells in the latter part of next summer, to determine whether the quality of the water differs materially in the drier portion of the year from its quality at the present time.

NANTUCKET.

SEPT. 4, 1902.

To the Board of Health of the Town of Nantucket, Mr. ROLLIN M. ALLEN, *Secretary.*

GENTLEMEN: — In response to your request for an examination of the water of the well where the town pump has been located in the village of Siasconset, and for advice as to the suitability of this water for drinking, the Board has caused the well and its surroundings to be examined and a sample of the water to be analyzed.

The well is located in the central portion of the village of Siasconset, which has no sewerage system, and there are numerous cesspools and other receptacles for sewage in its neighborhood.

The results of the analysis show that the water has been highly polluted by sewage and not thoroughly purified in its passage through the ground before entering the well, and, in the opinion of the Board, this water at the present time is unsafe for drinking.

It is possible that the quality of the water would be different at other seasons of the year, and its quality might change somewhat after a considerable quantity of water had been pumped from the well; but, in the opinion of the Board, it is unlikely that water which would be at all times safe for drinking can be obtained from this well.

NATICK.

JUNE 5, 1902.

To the Natick Water Board, Natick, Mass.

GENTLEMEN: — The State Board of Health received from you on May 22, 1902, an application for advice with reference to a proposed water supply for the town of Natick, to be taken from the ground on land owned by the town of Natick adjacent to Lake Cochituate, situated between the Worcester turnpike, the Saxonville branch of the Boston and Albany Railroad and Lake Cochituate.

The source indicated has already been thoroughly examined in previous years, and after a pumping test had been made by your board in the early part of 1898, this Board advised you (in a communication dated March 17, 1898, a copy of which is enclosed herewith) that, in the opinion of the Board, the source was an appropriate one for the supply of the town of Natick, and that the proposed works be constructed with a view to supplying the town wholly from this source in order that the use of water from Dug Pond might be discontinued.

Since the recent application was received the Board has again caused the territory to be examined by one of its engineers, and finds no material change in the circumstances which might affect a water supply taken from this place; and, after considering the results of previous investigations, the Board sees no reason to modify the advice already given.

NORTON.

JUNE 5, 1902.

To the Board of Health of the Town of Norton.

GENTLEMEN: — The State Board of Health has considered your application for advice with reference to a water supply for a proposed school building to be constructed in the south-westerly part of the village of Norton, and has caused the well, which it is proposed to use as a source of water supply, to be examined and a sample of the water to be analyzed.

The well is situated in a field quite remote from population at the present time, and, while an analysis shows that the water at the present time contains a considerable quantity of organic matter, it is probable that if the well were properly covered, so as to exclude surface water, water suitable for drinking could be obtained from this source. The circumstances are such, however, that it is doubtful whether this well will continue to be a suitable source of drinking water after the school house is built and water is drawn from the well in considerable quantity. The Board would advise that if this well is used as a source of drinking water by the school the water be analyzed from time to time to determine its quality.

PALMER.

MARCH 6, 1902.

To the Board of Health of the Town of Palmer, J. P. SCHNEIDER, M.D., *Chairman.*

GENTLEMEN: — In response to your application for advice as to the quality of the water of a spring in Palmer used for the supply of several families, the Board has caused the spring and its surroundings to be examined and samples of the water to be analyzed.

The spring from which the supply is taken is located near a small brook upon the slope of a hill west of the village of Palmer, and the water-shed of the brook above and about the spring is uninhabited.

The results of the examinations that have been made show that the water is of good quality for domestic purposes and safe for drinking. When visited, the basin in which the spring water is collected contained a considerable quantity of organic matter of vegetable origin which had evidently been accumulating for a considerable time. It is desirable that the basin in which the spring water is collected should be thoroughly cleaned and provision made for keeping vegetable matters from entering it.

It appears that a portion of the pipes through which the water is distributed is of lead, and an examination has been made to determine whether the water takes up lead in its passage through such pipes. The results do not show that the water acts upon the lead pipes to any considerable extent at the present time, but it is possible that at other seasons of the year or under other conditions considerable quantities of lead may be taken up by the water.

The Board would advise that analyses of this water be made at different seasons of the year to determine whether it is liable to act upon the lead pipes through which it is delivered to consumers to such an extent as to become injurious to health. The Board will make an examination of the water from time to time to determine its action upon lead, if you so request.

PLYMOUTH.

MARCH 6, 1902.

To the Board of Health of the Town of Plymouth, F. D. BARTLETT, *Secretary.*

GENTLEMEN: — The State Board of Health received from you on Aug. 16, 1901, an application for advice as to the quality of the water of a spring close to the shore of Plymouth harbor, near the foot of Chilton Street.

It appears that, changes having been made in the sewer system in that neighborhood and in the method of collecting and distributing water from the spring, it is desired to learn whether the quality of the water has been affected, since it is used by the public for drinking.

In response to your request the Board has caused the locality to be examined and several samples of the water of the spring to be analyzed. The results of the analyses indicate that the water has at some time been considerably polluted by sewage, but subsequently quite well purified in its passage through the ground to the spring. The water is much harder and somewhat less completely purified than the water of the Elder Brewster Spring, and it is probably safe for drinking, but, on account of the location of the spring, the quality of the water may deteriorate at any time, and if its use is to be continued it should be analyzed from time to time in order that any deterioration may be detected.

ROCKPORT.

SEPT. 4, 1902.

To the Water Commissioners of the Town of Rockport.

GENTLEMEN: — In response to your request for information as to the cause of the present bad taste and odor of the water of Cape Pond, from which the water supply of Rockport is drawn, and as to whether there is any remedy for this condition, the Board has caused the pond and its surroundings to be examined and samples of its water to be analyzed.

The results of the examinations show that the pond contains enormous numbers of the organism *Anabœna*, which is present in all parts of the pond, and the offensive taste and odor of the water, of which complaint is made, are evidently caused by this organism. The cause of the appearance of this organism in the waters of ponds and reservoirs is not known, nor is there any known method of preventing the appearance of such organisms. In ponds or storage reservoirs like Cape Pond, having muddy bottoms and considerable areas of swampy land on their water-sheds, such growths frequently occur, while ponds having sand or gravel bottoms, or reservoirs which have been thoroughly prepared for the storage of water by the removal of the soil and organic matter from their bottoms, are rarely seriously affected by organic growths, unless when the water entering the pond or reservoir is subject to pollution or affected by long contact with organic matter in swamps.

Cape Pond has a muddy bottom and a considerable area of swamp on its water-shed, and has evidently received much pollution in the past from the glue factory which has been located for many years on its water-shed. The removal of sources of pollution from the water-shed of the pond would have a tendency to decrease the growths of organisms and would improve the quality of the water, but it is not practicable to remove all the mud and organic matter from the bottom of Cape Pond, or to make such thorough improvements as would be likely to prevent the appearance of large numbers of organisms.

In the opinion of the Board the quality of the water of Cape Pond can be very greatly improved and probably made satisfactory for drinking and other purposes at all times by filtration through sand, and this appears to be the only practicable method of rendering the water of this pond satisfactory to consumers. In order to determine the means necessary for the satisfactory purification of this water, it will be necessary to make experiments upon the filtration of the water at times when it is affected by large numbers of organisms. The experimental filters could be located at the pumping station and the cost of the work would not be great.

If you decide to make experiments upon the purification of this water the Board will, if you so request, assist you by advising as to the construction of experimental filters and by making the necessary examinations of the water.

SALISBURY (WM. BEHAN).

AUG. 7, 1902.

MR. WILLIAM BEHAN, *Salisbury, Mass.*

DEAR SIR: — In response to your application of June 30 for advice as to the quality of the water of a driven well at Cushing Beach in Salisbury to supply a hotel, the Board has caused the well and its surroundings to be examined and samples of the water to be analyzed.

The results of the analyses show that the water has been polluted by sewage and not thoroughly purified in its passage through the ground before entering the well. The Board advises that the further use of the water from this well for drinking or cooking be discontinued.

SCITUATE.

MARCH 17, 1902.

To the Scituate Water Company, Scituate, Mass.

GENTLEMEN: — The State Board of Health has considered your application for advice as to taking an additional supply of water for Scituate from the valley of Bound Brook or of First Herring Brook in the town of Scituate, and has caused the present and proposed sources to be examined and samples of their waters to be analyzed.

It appears from the information presented to the Board, as to the yield of the tubular wells which form the present sources of supply, that the quantity of water is likely to be inadequate for the requirements of the town during the coming summer and that an additional supply must be provided. It is possible that further tests in the neighborhood of these wells might show that a considerable additional supply could be obtained in this valley, but the quality of the water of your present sources of supply appears to be somewhat unfavorably affected by population in the neighborhood of the wells, and it is doubtful whether a sufficient quantity of good water can be obtained for the supply of the town at all times within the limits of the area from which it appears to be permissible for the company to take water under its original act.

Analyses of water from Bound Brook and from First Herring Brook, the two sources mentioned in your application, show that both of these waters are highly colored and contain a large quantity of organic matter due to the contact of the water with vegetable matters in swamps. Moreover, the water-sheds contain considerable populations, and neither stream would be a desirable or a safe source of water supply for domestic purposes if the water should be taken directly from the stream.

Tests which have been made by the Cohasset Water Company in the lower portion of the valley of Bound Brook, where the course of the stream is within the limits of Scituate, have not shown any place from which it appears to be practicable to obtain water of good quality from the ground.

There are several places in the valley of First Herring Brook where the conditions appear to be favorable, judging from surface indications, for obtaining good water from the ground in considerable quantity, and the Board would, therefore, advise that further investigations and tests by means of tubular wells be made in the valley of First Herring Brook.

The Board will assist you in these investigations by making the necessary analyses of samples of water, and will give you further advice in the matter when the results of further investigations are available.

SHIRLEY.

NOV. 6, 1902.

To the Water Supply Committee of the Town of Shirley, FRED D. WEEKS, THOMAS L. HAZEN, JAMES P. TOLMAN.

GENTLEMEN: — The State Board of Health has considered your application for advice with reference to a proposed water supply for the town of Shirley to be taken from a well which it is proposed to locate near the brook which flows through the village about 300 feet east of the No. 2 mill of the Samson Cordage Company, and has caused the locality to be examined by one of its engineers.

The place at which it is proposed to locate the well is at the foot of a steep bluff on the southerly side of the brook, where ground water percolating toward the river from the high plain to the southward finds an outlet. While there are no means of obtaining a sample of water from the ground at the proposed location of the well, an analysis of the water of a spring located not far from the proposed well, and analyses of the water of the well from which the supply of the cordage works is now drawn, which is located about 250 feet up stream from the proposed well, show that the waters of both of these sources are of excellent quality for purposes of a public water supply, and it is probable that these sources represent the character of the ground water in the neighborhood.

No tests of the character of the soil at the site of the proposed well have been made which would furnish definite evidence as to the quantity of water obtainable at this place, but the circumstances of the location and apparent character of the soil, together with the indications furnished by the yield of the well at the cordage works, are indications that a sufficient quantity of water can be obtained in this locality for the requirements of Shirley.

The Board is of the opinion that the indications furnished by the investigations thus far made are sufficiently favorable to warrant further tests at this locality, and that if it is found to be feasible to obtain an ample supply of water from a well or wells at this place, of a quality similar to that obtained from the well and spring, this source would be an appropriate one for the town of Shirley.

SOUTHBOROUGH.

JULY 3, 1902.

To the Board of Health of the Town of Southborough, MR. CHARLES L. FAIRBANKS, *Chairman.*

GENTLEMEN: — In response to your application for advice as to a water supply for the public schools of Southborough, in the centre of the village, in which you indicate four wells as available sources of supply, the Board has caused the surroundings of these wells to be examined and samples of their waters to be analyzed.

The first well, situated on the easterly side of the Marlborough road and used at the present time as a source of supply for a private house, is located at a considerable distance from sources of pollution. The analysis of the water shows, however, that it has been at some time polluted by sewage but subsequently well purified in its passage through the ground, and is probably, in the condition in which it was found at this time, a safe source of drinking water supply. The water, however, is harder than is desirable, and a change in the circumstances attending the pollution of the water may at any time render it unsafe for drinking, and considering these circumstances the Board cannot recommend this well as a source of water supply for the public schools of the town.

The water of the second well examined, located in a field in the rear of the town hall, and of the third well, situated immediately back of the town hall, was found to be of poorer quality than the water of the first well examined, while the fourth well, located in the high-school lot about 100 feet from the main street, gave evidence at this time of the presence of unpurified sewage, and the Board would advise that further use of water from the latter well be prevented without delay.

The Board would advise that you have investigations made with a view to securing a supply of water for the schools from the ground at some place near the village where the water is not subject to pollution by sewage. A supply of well or ground water will have decided advantages over a supply from any surface water source.

SPRINGFIELD.

APRIL 3, 1902.

To the Board of Water Commissioners of the City of Springfield, C. L. GOODHUE, *Chairman.*

GENTLEMEN: — The State Board of Health received from you on June 28, 1900, the following application for advice as to the water supply of the city of Springfield: —

> The city of Springfield desires the advice and co-operation of your Board in the matter of the experimental filtration of the waters of the Ludlow and Jabish Brook sources. It is the intention of the city to construct an experimental filter plant, of such design and capacity as may meet the approval of your Board, and to maintain and operate such plant under all climatic conditions, for such length of time and in such manner as your Board may suggest, with a view to determining conclusively
>
> *First.* — Whether or not these waters can, by filtration, be made always suitable in quality for the future permanent uses of the city.
>
> *Second.* — Whether or not, from all the results reached by the experiments, the purification by filtration of all the water which these sources may by further development of capacity be made to yield would be the most economical, practi-

cable and appropriate method of providing the city with a satisfactory supply of water for the period of years extending forward to the time when the limit of the enlarged capacity of the sources will be reached.

Subsequently the experimental filter plant proposed in the application was constructed at Ludlow Reservoir, and provision made for carrying on experiments for the purification of the water of the reservoir and of the canal conveying water from Jabish Brook and other streams to the Ludlow basin. The filter plant was of ample size and capacity for carrying on experiments on a sufficient scale to determine the feasibility of the purification of the waters of these sources, and to form a basis for an estimate as to the probable cost of the necessary works.

The filtration plant was operated from near the end of December, 1900, to Feb. 1, 1902. During this time the Board has co-operated with you in the general operation of the experiments, and has made the necessary chemical, microscopical and other analyses and observations upon the character of the waters and the operation of the filters, the results of which have been furnished your engineer from time to time.

Numerous analyses of the water of Ludlow Reservoir have been made by the Board during the last fifteen years, and consequently much information is available as to the general character of the water of this source. Under usual conditions the water of the reservoir has a very objectionable taste and odor during much of the warmer portion of the year on account, chiefly, of the presence of the organism *Anabœna* in great numbers. The water is also sometimes very objectionable in the latter part of the winter and early in the spring on account of the presence of great numbers of certain *Infusoria*.

The results of all the examinations of this water during the year 1901, when compared with those of previous years, show that the water during 1901 contained, on the whole, less organic matter and was in other respects less objectionable than was the case in any of the previous years, excepting those immediately following the previous drawing off and refilling of the reservoir.

The condition of the water in the winter and spring of 1901 was not materially different from its condition at this season in other years, and the experiments carried on during this time were carried on under conditions such as have usually existed at this season of the year.

In the later spring and early summer, on the other hand, the quality of the water was better than usual, and in the months of June and July it was better than has ever been known before during these months. The quantity of organic matter in the water increased rapidly in August, great numbers of *Anabœna* appearing in the water, and from early in August until after the middle of September, a period of about six weeks, the quality of the water was as bad as ever known at this season of the year. After the middle of September, however, the quality of the water improved rapidly and became, during the remainder of the year, much better than in the latter part of any previous year.

The principal filter used in the experiments upon the purification of Ludlow Reservoir water contained, above the underdrains, about 5 feet of medium sand a little coarser than that in the filter of the city of Lawrence. This sand was used because it appeared to be well adapted for the purpose, and a large quantity of it appeared to be easily available in the neighborhood for the construction of filters if necessary. This filter was operated, except for a short time, as a continuous filter at a rate of 2,500,000 gallons per acre per day, and in the latter part of the year at a considerably higher rate, and was successful in removing the objectionable odors from the reservoir water except at the time of the presence of the excessive quantities of organic matter in August and September, when the effluent of the filter had for a time the odor characteristic of the water of the reservoir and in nearly as pronounced a degree.

The results obtained by filtering the water through other similar filters at a rate nearly twice as great as that employed during the greater part of the year with the large filter were nearly equal to those obtained with that filter. None of the filters, however, to which Ludlow Reservoir water was directly applied removed the characteristic odor from the reservoir water during the time in August and September when this water contained excessive quantities of organic matter.

An experiment upon the refiltration of the reservoir water was begun early in August and continued until the end of the experiments. This experiment consisted in applying the effluent of the large filter to another similar filter at a much more rapid rate. This secondary filter successfully removed the taste and odor from the effluent of the larger filter, and the effluent of the secondary filter was at all times during its operation of good quality and suitable for the purposes of a public water supply.

The results of the experiments indicate, in the opinion of the Board, that it will be possible to purify Ludlow Reservoir water by a system of double filtration, so that the water will be freed from the disagreeable taste and odor which now make it so objectionable for domestic uses during much of the year.

Experiments were made upon the purification of the canal water with similar filters and in a similar manner to that employed in the filtration of the reservoir water.

During the year 1901 the canal water contained much smaller quantities of organic matter and organisms than were found in the reservoir water, and the largest numbers of organisms were present at a time when water from Belchertown Reservoir entered the canal accidentally. The water of the canal is much more highly colored under ordinary conditions than the water of the reservoir, and a smaller proportion of the color was removed by filtration.

The results show that, under conditions similar to those which existed in 1901, objectionable tastes and odors and a considerable portion of the organic matter can be removed from this water by filtration, and the color can be noticeably reduced so that this water would be of good quality for the purposes of a public water supply, though the color would probably at times be quite noticeable.

In response to your second question, "Whether or not, from all the results reached by the experiments, the purification by filtration of all the water which these sources may by further development of capacity be made to yield would be the most economical, practicable and appropriate method of providing the city with a satisfactory supply of water for the period of years extending forward to the time when the limit of the enlarged capacity of the sources will be reached," — the Board has considered the probable future requirements of Springfield in the matter of a public water supply, the capacity of Ludlow Reservoir and tributary water-sheds, and the feasibility of supplementing the supply from those works in the future.

The Ludlow and Jabish Brook sources, as developed at present, will become insufficient for the supply of the city within a very few years in the future. The present canals are incapable of carrying the flow of the streams during the period when the flow is highest. A material increase in the yield of the sources could be made by enlarging the capacity of the canals, and, if the canal from Jabish Brook should be enlarged so as to be capable of carrying the whole flow of that stream, it is probable that enough water could be obtained from the Ludlow source for the supply of the city of Springfield for the next ten years; after that time it would be necessary to supplement the supply from some other source, unless a material reduction should be made in the consumption of water per person.

The best available source from which to supplement the supply is the Swift River, from which water can be taken either by gravity from the west branch of the stream or by pumping from the main stream lower down. Water from the west branch can be conveyed to the Ludlow Reservoir by gravity through a conduit estimated by your engineer to be about 17 miles in length and to cost about $900,000. Water can be pumped from the river at a point just above Duckville at a much smaller expense. The water of the Swift River at the point from which it could be taken by gravity would be of excellent quality for all domestic purposes, and might be supplied to the city without filtration, but the yield of this source in the summer season would be a small proportion of the quantity required for the supply of the city by the time this source would be introduced; and it is likely, moreover, that if the plan of taking water from the Swift River by gravity should be adopted the capacity of the works would be reached again in less than forty years. If water should be pumped from the Swift River in the neighborhood of Duckville a supply would doubtless be secured sufficient to last for more than forty years in the future. It thus appears that the development of an adequate supply of water for Springfield from the Ludlow Reservoir and Jabish Brook sources will require, first, a filtration plant, and, subsequently, an enlargement of the canals supplying Ludlow Reservoir, and in about ten years the construction of works for taking water from the Swift River.

The only other available source from which it appears to be practicable to obtain a large quantity of good water at reasonable expense is the east branch of the Westfield River, above the town of Huntington. In a previous communication regarding the use of this stream as a source of water supply for Springfield early in 1900 the Board advised that, in its opinion, this stream was an appropriate and would be a satisfactory source of water supply for that city. The water of the east branch of the Westfield River, with a suitably constructed reservoir, would probably be at least equal in quality to the water of the Ludlow and Jabish Brook sources after filtration.

A comparison of the estimated cost of engineering structures and mill damages for taking water from the Westfield River, with the estimated probable cost of filtering the Ludlow and Jabish Brook sources and making the necessary additions and enlargements, indicates that the cost of a supply from the Westfield River is likely to be less to the city of Springfield than the cost of a supply from the present sources developed to their fullest capacity, and very much less than the cost of a supply from the present sources increased by water from Swift River, which increase would probably be required within ten years.

Having considered the results reached by the experiments and the information relative to the various sources, the Board is of the opinion that the east branch of the Westfield River, above Huntington, would be the most appropriate and satisfactory source of public water supply for the city of Springfield.

May 23, 1902.

To the Board of Water Commissioners of the City of Springfield, Mr. Charles L. Goodhue, *Chairman.*

Gentlemen: — On April 3 the State Board of Health sent you a reply to your application for advice as to the feasibility of improving the quality of the Ludlow and Jabish Brook sources, and as to the most appropriate source of water supply for Springfield for the future. In this communication the Board presented its general conclusions upon the results of the investigations and experiments upon the filtration of the Ludlow and Jabish Brook sources carried on during the year 1901 and in the early part of 1902. The results of the analyses and of observations upon the experiments were reported to you, or to your engineer, from time to time as the work progressed. These results have been brought together and summarized in a report of the chemist of the Board, and the Board now sends you this report, which contains in detail the results of all the various experiments upon the filtration of the Ludlow and Jabish Brook waters carried on at your experiment station at Ludlow Reservoir in the years 1901–1902.

Stoughton.

Sept. 4, 1902.

To the Board of Health of the Town of Stoughton.

Gentlemen: — The State Board of Health received from you on August 14 a communication requesting advice as to the condition of certain wells in the town of Stoughton, and subsequently the Board caused the wells indicated by you to be examined by one of its engineers and samples of their waters to be analyzed. One of the wells indicated is located on the Morton estate in Morton Square in the central portion of the village of Stoughton, and the other at the corner of Pearl and Central streets.

The results of the analyses show that the water of both wells is greatly polluted by sewage, evidently derived from the sink drains and cesspools in their neighborhood.

The Board would advise that the use of water from these wells for drinking or cooking be discontinued.

Sturbridge (Fiskdale Mills).

Aug. 7, 1902.

Mr. Franklin D. Williams, *Treasurer Fiskdale Mills, Boston, Mass.*

Dear Sir: — In response to your application for advice with reference to a supply of water for the Fiskdale mills and the tenements in their neighborhood in Fiskdale, the Board has caused the locality to be examined by its engineer, and samples of water from test wells and other possible sources of water supply in the neighborhood to be analyzed.

At the time the application was submitted in September, 1900, a reservoir was being constructed upon a hill south of the village to furnish pressure for fire service about the mills, and test wells were being sunk in the low land on the south side of the river opposite the mills. Samples of water collected from these test wells from time to time up to the beginning of winter were found to be of good quality, but further investigation was then discontinued. In June of last year several of the wells were connected and a pumping test was made by pumping from them for a period of several days in order that the probable quantity and quality of water to be obtained from these wells might be determined, and several samples of the water were collected and sent in by you while the test was in progress. The results of the analyses of these samples show that the water, while somewhat hard, is in all other respects of excellent quality for the purposes of a water supply. The quantity of water which these wells were capable of furnishing was found, however, to be very limited, and probably insufficient even for the present supply of the mills and tenements. Further tests were then made by means of other wells in this neighborhood, but the information furnished by your engineer as to the results of the further tests indicates that the area containing porous soil which will yield water freely is quite limited, and that it is improbable that an adequate supply of water can be obtained from the ground in this region.

There does not appear to be any other place in the immediate neighborhood of the mills from which it is likely that an adequate ground-water supply for the village could be obtained. It might be possible, by the construction of a reservoir upon one of the small streams flowing from the higher land south of the river, to secure an adequate supply of water for the village and mills by gravity, but the cost of the necessary works would be large.

As already indicated, a portion of the wells are located in porous soil, and if water could be applied in considerable quantity to the ground near these wells the yield of the wells could doubtless be increased. It is practicable to convey water by gravity from the upper dam or canal to the ground about the wells, and, by applying the water intermittently and at a considerable distance from the wells, the quality of the well water would probably not be affected unfavorably.

It would be practicable to filter the water of the Quinebaug River and in this way secure a supply of water that would be of good quality for drinking, but the cost of a satisfactory supply of filtered water obtained in this way would be considerably greater than the cost of a supply from tubular wells supplemented in the manner outlined.

Considering the conditions, the Board would advise that you make another test of the wells by applying water to trenches or prepared areas in their neighborhood, and determine by pumping from the wells whether the water filters into them through the ground, and whether the yield can be made in this way sufficient for the requirements of the mill properties. The Board will assist you in the investigation by making such analyses of samples of water as may be necessary, and will give you further advice in the matter when the results of a further test are available.

SUNDERLAND.

MARCH 6, 1902.

To the Board of Selectmen of the Town of Sunderland.

GENTLEMEN: — In response to your application of February 17 for advice with reference to the use of Sawmill Brook as a source of water supply for the village of Sunderland, the Board has caused the proposed source to be examined by its engineer and samples of water sent in by you to be analyzed.

The results of the analyses show that at the present time the water of Sawmill Brook has but little color and is in other respects of good quality for the purposes of a public water supply, and the source does not appear to be exposed to danger of pollution, since the water-shed is uninhabited. While no measurements of the flow of the stream in dry weather are available to the Board, the size of the water-shed is such that it is probable that this source can be made to yield an ample supply of water for the requirements of the town.

It is not practicable to determine from analyses made at this season of the year the probable quality of the water at other seasons, but, so far as can be judged from the investigations that have been made, the Board is of the opinion that Sawmill Brook at the point at which it is proposed to take the water would be an appropriate source of water supply for Sunderland.

Tewksbury.

Nov. 6, 1902.

To the Water Supply Committee of the Town of Tewksbury, Edwin C. Gerrish, *Chairman*, William Dixon, Henry M. Billings, J. Lewis Burtt, Benjamin Spaulding, *Secretary*.

Gentlemen: — The State Board of Health received from you on June 2 an application for advice with reference to a proposed water supply for the town of Tewksbury containing the following statement of your proposed plans: —

> The water supply is for the town of Tewksbury and to embrace both Tewksbury Centre and the settled portions at North Tewksbury and along the Lowell line.
>
> Advice is asked in regard to the supply being taken from the vicinity of Strongwater Brook near the Salem Junction station, at a point about 1,700 feet below the present supply for the State almshouse. The committee believe that an abundant supply of pure water can be obtained at this point, and that no interference with the supply of the State almshouse will be occasioned should the town supply be taken from this point.
>
> A large number of experiments have been made in this vicinity in connection with the State institution supply, and the indications are that there is a very large amount of ground water in this locality which will be ample to supply all demands, both of the institution and town.
>
> The location of the supply below that of the institution will not, in our opinion, affect the supply taken from above at the present pumping station of the State almshouse.
>
> Your opinion of the adequacy of this locality to supply the town of Tewksbury without endangering the almshouse supply is desired.
>
> If, in your opinion, it is necessary to make further investigations at this point before rendering a positive opinion on this matter, the committee desire to be so informed and would desire you also to indicate the nature of such investigations.

A second source of supply is also contemplated at the Shawsheen River from the subsoil near Burtt station. The committee will make investigations by means of driven wells at this point. As this latter point is directly away from the village, and more expensive thereby than the Strongwater Brook location by about $12,000 to $14,000, it is the opinion of the committee that the first-named location is the best for the town. The location of the sewage disposal field from the State almshouse when put in may also be of importance, and our committee desire your advice in regard to the probable location of this field so that its effect on any source selected may be determined.

Soon after this application was received a series of tests of the ground in the valley of Strongwater Brook were begun, both above and below the wells at present used as sources of supply for the Tewksbury almshouse, and tests were also made at many places in the valley of the Shawsheen River.

The waters of all of the test wells in the valley of Strongwater Brook, both above and below the present wells of the Tewksbury almshouse, were found to be strongly impregnated with iron, which would make them objectionable for many uses, and at nearly all of the places tested in the valley of the Shawsheen River a similar condition was found. Finally, tests were made in the valley of the Shawsheen River in the southerly part of the town near Heath Brook, and at this place the ground water was found to be of excellent quality. The three test wells at this place all yielded water freely in large quantities when pumping with a hand pump, and the indications furnished by this test are, in the opinion of the Board, favorable to obtaining at this place a sufficient quantity of water of good quality for the supply of the town of Tewksbury from wells or other suitable works.

On August 26 the Board received through your engineer, Mr. E. Worthington, a request for its opinion upon the following points: —

First. — Is the present supply of the State hospital capable, with proper development, of yielding an abundant quantity of water for both hospital and town?

Second. — In view of the present plant at the hospital as regards fire protection, would not the supply from a large storage reservoir, with the pressure as indicated herein, be a material advantage to the institution in fire protection?

Third. — If an agreement can be made through commissioners or otherwise between the hospital trustees and the town of Tewksbury with regard to a union supply to be taken from the present source of the hospital, would it not be a material advantage both to the State and town?

In the opinion of the Board the experience furnished by the test of the wells now used as a source of water supply for the State hospital, and by the use of these wells during the past year, shows that this source, with the addition of further wells when necessary, is probably capable of furnishing a sufficient supply of water for both the town and the hospital at the present time, and there is little doubt, judging from the information available to the Board, that the expense of supplying water to the town and hospital will be much less in case works are operated jointly than if separate works are maintained for each.

In the opinion of the Board the source at present used for the supply of the State hospital would be an appropriate and satisfactory one for both the town and the hospital. In case suitable arrangements for a joint supply cannot be made, the Board is of the opinion that the ground in the vicinity of Heath Brook near the Shawsheen River affords a good opportunity, as shown by the recent investigations, for obtaining an adequate supply of good water for the town.

It is possible that further tests in the valley of Strongwater Brook above the hospital wells might show that it is practicable to obtain water of good quality by locating the wells in the upland adjacent to the meadow and swampy land through which the brook flows.

WATERTOWN (HALE HOUSE FARM).

MAY 15, 1902.

To Mr. G. W. LEE, *Chairman of Committee on Hale House Farm, Watertown.*

SIR: — In response to your request of May 5, the State Board of Health has caused an examination to be made of two wells indicated by you on land bordered by Bailey Road and the Oakley Country Club in Watertown, which you propose to use for sources of water supply for a small institution.

One of the wells was found, upon examination, to be filled with stones, and a sample of the water could not be obtained for analysis. A sample of water from the remaining well has been collected and analyzed, and the results show that it contains at present a greater quantity of organic matter than is usually found in good ground waters.

In the opinion of the Board it is probable that, if the latter well should be thoroughly cleaned out and provision made for preventing polluting matters from entering it from the surface, the water would be safe and of satisfactory quality for drinking so long as its immediate water-shed remains uninhabited.

WELLESLEY (WELLESLEY COLLEGE).

AUG. 7, 1902.

To the Trustees of Wellesley College, Wellesley, Mass., Mr. E. O. PERKINS, *Superintendent.*

GENTLEMEN: — In response to your request received July 7 for advice relative to a proposed auxiliary water supply for the college, which will be used to some extent for drinking, the Board has caused the proposed source of supply to be examined and samples of the water to be analyzed.

The results of the analyses show that the water is slightly turbid and colored, and the water of one of the samples had a very faintly unpleasant odor on heating. The water contains a larger quantity of organic matter than is found in good ground waters, and it is evident that it has been at some time slightly polluted and not thoroughly purified in its passage through the ground before reaching the place at which the samples were collected.

An examination of the surroundings of the sources from which the water is derived shows that they are exposed to danger of pollution by sewage, and it is not unlikely that the water is of poorer quality at some seasons of the year than it was found to be at the time this examination was made.

Considering the circumstances, the Board is of the opinion that this water is not safe for drinking.

WHATELY.

JUNE 5, 1902.

To the Committee on Water Supply of the Town of Whately.

GENTLEMEN: — The State Board of Health has considered your application for advice with reference to a proposed water supply for the town of Whately, to be taken from Roaring Brook, and has caused the proposed source of supply to be examined by its engineer and a sample of the water to be analyzed.

The results of the analysis show that the water is of good quality for the purposes of a public water supply. It will be necessary to guard against danger of pollution of the source from buildings on the watershed.

Regarding the quantity of water which this source will yield, the Board is unable to express a definite opinion at the present time; but, so far as can be judged from the information available, it seems likely that the natural flow of the brook will furnish a greater quantity of water at all times than would be required for the supply of Whately, and it appears to be practicable to increase the yield of the source by the construction of storage reservoirs at some future time, if it should be found necessary or desirable to do so.

In the opinion of the Board, Roaring Brook is an appropriate source of water supply for the town of Whately. The Board is further of the opinion that Roaring Brook is an appropriate source of water supply for the village of South Deerfield also, and that the right to take a water supply from Roaring Brook should not be granted to Whately to the exclusion of the village of South Deerfield.

WHITMAN.

JAN. 23, 1902.

To the Water Commissioners of the Town of Whitman.

GENTLEMEN: — The State Board of Health received from you on Jan. 17, 1902, an application for advice with reference to a proposed water supply for the town of Whitman, in which you state that your plan is to construct a filter-gallery and pumping station near the shore of Oldham Pond, situated in the towns of Hanover and Pembroke, and to provide a pipe for drawing water from Maquam Pond, which is located near Oldham Pond and at a higher level, to the proposed pumping station, using the water of Maquam Pond so long as the quantity furnished may be sufficient, and supplementing it in the future, when necessary, by water drawn from a filter-gallery near Oldham Pond.

The Board has carefully considered your proposed plan and has caused the locality to be examined by its engineer. The topography and the character of the soil in the region between Maquam and Oldham ponds, so far as can be judged from surface indications, are favorable to obtaining a large yield of water from the ground by means of wells or a filter-gallery, the most favorable location for which would probably be not far from the shore of Oldham Pond; and if, upon a thorough test of the ground in this region, it should be found that good water can be obtained freely in large quantities, the proposed plan of using water from Maquam Pond, supplemented with water drawn from a filter-gallery or wells in the region near Oldham Pond when necessary, would furnish, in the opinion of the Board, an adequate supply of good water for the town.

A good ground water, on account of its freedom at all times from color, taste and odor, would, however, be more satisfactory for the purposes of a public water supply than the water of Maquam Pond, which, though it may usually be of excellent quality, is evidently affected at times, in common with the water of many similar ponds, by an unpleasant taste and odor; and if a large quantity of ground water should be found to be obtainable in the region indicated in your application, it would be best for the town to use this water, supplementing the supply if necessary with water drawn from Maquam Pond.

The Board would advise that you cause thorough investigations to be made, with the assistance of an engineer of experience in matters relating to water supply, of the feasibility of securing a sufficient supply of water of good quality for the town from the ground in the neighborhood of Oldham Pond. The investigations should include sufficient tests of the ground near Oldham Pond to determine definitely the probable quantity and quality of ground water to be obtained there. If the results of the tests near this pond should be unfavorable, investigations should be made of other plans by which it may be possible for Whitman to obtain a satisfactory public water supply from Maquam and Oldham ponds or the region about them. These possible plans have already been indicated in a previous reply of the Board upon this subject.

The Board will co-operate with you in these investigations by making the necessary analyses of samples of water, and will give you further advice in the matter when you have the results of further investigations to present.

JAN. 23, 1902.

To the Board of Health of the Town of Whitman.

GENTLEMEN: — The State Board of Health, in response to your request, has caused the well of the Gurney school on Warren Avenue and its surroundings to be examined and samples of the water to be analyzed.

The results of the analyses show that the water has at some time been considerably polluted by sewage, but subsequently quite well purified before entering the well. While, in the opinion of the Board, the examinations do not show that the water is, in its present state, unsafe for drinking, the sources from which the pollution of the water is evidently derived are located at no great distance, and a change in the conditions affecting the pollution of the water may at any time render it unsafe for drinking.

The Board would advise that, if the use of this well should be continued, the water be analyzed from time to time in order that any deterioration may be detected. This source of supply is not one to be desired, and should be discontinued when a public water supply that may safely be used for drinking is available.

WORCESTER.

MARCH 6, 1902.

To Mr. ARTHUR P. RUGG, *City Solicitor, Worcester, Mass.*

DEAR SIR: — In response to your application of February 24 for the advice and recommendation of the State Board of Health as to the proposed plan of the city of Worcester to take water from the "area recommended for the city of Worcester," in the report of the State Board of Health of 1895 relative to a water supply for the metropolitan district, and shown upon the map accompanying said report opposite page 48, the Board has further considered the proposed plan.

A comparison of the estimated capacity of your present sources of water supply with the records of the quantity of water used by the city during the past few years shows that at the rate of increase of the past few years the consumption of water in the city will very soon equal the capacity of your present works, and an additional supply is required.

The water-sheds of Asnebumskit and Kendall brooks lie contiguous to your present sources of water supply, and it is apparently feasible to divert the waters of these streams, and of an area of water-shed lying between them, into one of your present storage reservoirs by gravity. The water-sheds of these brooks are sparsely populated, and it will be practicable for the city to secure water of good quality from these sources at a comparatively small expense.

The Board is of the opinion that Asnebumskit and Kendall brooks and the water-shed lying between them, approximately as shown upon the plan above referred to, are appropriate sources of additional water supply for the city of Worcester.

SEWERAGE AND SEWAGE DISPOSAL.

The following is the substance of the action of the Board during the past year in reply to applications for advice relative to sewerage and sewage disposal: —

BRIDGEWATER.

DEC. 4, 1902.

To the Sewerage Committee of the Town of Bridgewater, W. F. WHITMARSH, M.D., *Chairman.*

GENTLEMEN: — The State Board of Health received from you on Aug. 2, 1902, an application for advice relative to a proposed system of sewerage and sewage disposal in the town of Bridgewater, containing the following outline of your proposed plan: —

> Accompanying this application are the plans submitted by our engineers, Snow & Barbour, Boston; also their report and recommendations.
>
> The system of sewers proposed is the so-called separate system, and a gravity outfall to the disposal works is shown to be possible for either of two locations, plans of both being herewith submitted. The Town River location is 12 feet lower than the South Brook site, but the disadvantage, if such it may be called, of the Town River location, is its proximity to the water works pumping station. The adoption of the South Brook site will require the pumping of the sewage of the shoe factory, but all territory of the village lying above this factory can be sewered by gravity.
>
> The disposal works comprise artificial sand filters and preliminary treatment of the sewage in a septic tank, plans of which are herewith submitted. We desire to be advised particularly with respect to the Town River and South Brook locations.
>
> Also with respect to the advisability of using the Bassett lot.

The application was accompanied by plans, submitted by your engineers, Messrs. Snow & Barbour of Boston, and by their report and recommendations.

The plans provide for the collection of the sewage in a system of pipe sewers, and for purifying it at one of the localities mentioned by first passing the sewage through septic tanks having a capacity of 250,000 gallons, and subsequently, after aeration, filtering the sewage through sand filter-beds at a rate of from 100,000 to 150,000 gallons per acre daily, the effluent to be discharged either into Town River or South Brook, according to the site selected for the location of the disposal works.

The estimated cost of the disposal works, including land, the septic tanks and one acre of sand filter-beds, is $17,300. The cost of each added acre of filter-beds is estimated at $9,500.

The Board has caused the areas indicated as locations for purification works to be examined by its engineer, and has carefully considered the plans and report submitted therewith.

The Bassett lot is not, in the judgment of your engineers, a desirable place of sewage disposal, an opinion in which the Board concurs. Two other places are indicated as possible locations for disposal works, one near the Town River and the other in the valley of South Brook, and the plans submitted give outlines of disposal works at each of these locations.

The location near the Town River is about 600 feet from the water works pumping station and close beside a small pond used as a source of water supply by the Bridgewaters Water Company. This location has the advantage that practically all of the sewage of the thickly settled portions of the town could be brought to it by gravity, but the soil at this place is not suitable for the purification of sewage, and, owing to possible danger of the pollution of the sources of water supply of the town from sewage-disposal works located in such close proximity to them, the Board is of the opinion that this location is not a suitable one for the disposal of the sewage of Bridgewater.

In the South Brook valley soil is found on the southerly side of the brook suitable for the purification of sewage, and purification works could, in the opinion of the Board, be located in this valley sufficiently remote from dwelling houses to be unobjectionable, and the sewage could be efficiently purified so that it would not create an objectionable condition in the stream. It is desirable to locate the purification works farther east of the railroad than indicated on the proposed plan.

The plan of collecting the sewage into a system of pipe sewers from which surface and ground water will be excluded, as proposed, will be the best for the town of Bridgewater to adopt, and it will be desirable to provide underdrainage beneath the sewers where trouble is experienced from wet cellars, or where there is likely to be leakage of ground water into the sewers. If no sewage is allowed to be discharged from the sewers or house connections into the underdrains the water from these drains can be allowed to flow into local water courses without danger of creating offence.

It is necessary that the sewage shall be well purified, both as regards the removal of organic matter and of bacteria, in order to prevent objectionable conditions in the valley of South Brook below the works and also on account of the fact that the Taunton River, into which the effluent will find its way, is used as a source of water supply.

The use of the septic tank in this case is, in the opinion of the Board, unnecessary, since a well-purified effluent can be obtained without its use by the ordinary process of intermittent filtration on ground that can be made available for this purpose and at a rate which is entirely reasonable. Moreover, the cost of the purification of the sewage of Bridgewater by such filtration is likely to be considerably less than the cost of efficient purification by the system proposed.

The Board would advise the construction of filter-beds, having an aggregate area of from three to four acres with a depth of filtering material of at least 4 feet and 5 feet over the underdrains. Enough land should be acquired to allow for enlarging the filter-beds in the future, to provide for the growth of the town.

It appears to be impracticable to collect the sewage from a portion of the village in the neighborhood of the railroad station and easterly therefrom into the proposed sewerage system by gravity if the disposal works should be constructed in the valley of South Brook, and provision for pumping the sewage from some of the territory near the railroad station will be necessary. This can doubtless be done at no great expense to the town. The omission of the proposed septic tanks from your plan will make it practicable to deliver the sewage at the filtration area at a lower level, and possibly reduce considerably the area from which it will be necessary to deliver sewage into the system by pumping.

Hull (Fort Revere).

July 3, 1902.

To Capt. Alfred M. Palmer, *Depot Quartermaster, U. S. A., 170 Summer Street, Boston, Mass.*

Dear Sir: — The State Board of Health received from you on June 20 an application for advice relative to a proposed sewer system at the post of Fort Revere, Hull, Mass., accompanied by plans showing the location of the proposed sewers and the proposed outlet on Stony beach, near the northerly shore of the town of Hull, at a point about 125 feet from shore and 65 feet inland from the line of low water.

The Board has caused the locality to be examined by one of its engineers and has carefully considered your application and the plans submitted therewith. The proposed sewers, so far as can be judged from the information submitted, are of suitable size and are adapted for the collection and removal of all of the sewage of the post as proposed at the present time. The proposed method of disposing of the sewage by discharging it into the sea is the best that it is practicable to adopt. It is very important, however, that the outlet be extended beyond the line of extreme low water, so that the danger that floating matters from the sewage will collect among the rocks, where they will be liable to be offensive at low tide, will be avoided. It is understood that the outlet is to be composed of iron pipe and that no tide gates will be provided. Tide gates will not be necessary under these circumstances, and the sewage may reasonably be allowed to discharge at all times.

LANCASTER.

SEPT. 4, 1902.

To the Board of Health of the Town of Lancaster, Dr. C. C. BECKLEY, *Secretary.*

GENTLEMEN: — The State Board of Health received from you on August 15 a communication requesting its advice relative to the disposal of the sewage from the town buildings and other buildings at Lancaster Centre.

In June of last year, in response to an application for advice relative to the disposal of the sewage of the sanitarium and other buildings in South Lancaster, the Board advised that the conditions existing there were a menace to the health of the neighborhood, and that it was important that sewage be collected and disposed of in some suitable manner, and a copy of the advice of the Board was sent you at that time with the suggestion that the matter be committed to an engineer of experience in questions relating to sewage disposal. You were also advised that the question of the sewerage of the town in general be taken into consideration in order that sewers or other works which might be constructed for the relief of the district under consideration at that time might form a part of a general system.

The Board is unable to give you any further advice than this at the present time. It is especially important that, before you build sewers or disposal works for any district in the town, the sewerage of the whole town be carefully considered in order that sewers or disposal works which may be built for the relief of any district or districts may form a part of the general system in the future.

The best course for the town to pursue, under the circumstances, in removing the existing objectionable conditions and providing proper disposal for its sewage is, in the opinion of the Board, to employ an engineer of experience in matters relating to sewage disposal to prepare a plan for the collection and disposal of all of the sewage of the thickly settled portions of the town where sewerage seems likely to be required. Such portions of the works as may be required can then be built from time to time. When a plan has been prepared the Board will, upon receipt of the plan, give it careful consideration and advise you concerning it.

MANCHESTER (ESSEX COUNTY CLUB).

NOV. 6, 1902.

To the Essex County Club, Manchester, Mass.

GENTLEMEN: — The State Board of Health received from you on October 23 a plan of a proposed system for the disposal of the sewage of your club house at Manchester, presented by your engineer, Mr. A. D. Fuller of Boston, with the request that the Board advise you as to its suitability for the purpose, the quantity of sewage to be disposed of being usually about 1,600 gallons per day in summer, as determined by observations made by your engineer.

The plan provides for collecting the sewage into a settling tank from which it will flow into two sub-surface filter-beds, having a total area of 1,280 square feet, the effluent from which will be discharged into a third sub-surface filter-bed, having an area of 600 square feet, whence it will flow into a meadow and find its way eventually into Sawmill Brook.

Provision is made for flushing the pipes through which the sewage is to be distributed to the first two beds by carrying the distribution pipes through the beds so that the sewage used in flushing will be discharged upon the ground outside of the bed.

The Board has caused the proposed location of the purification works to be examined by one of its engineers, and, having carefully considered the proposed plan, is of the opinion that the works proposed are capable of purifying the sewage efficiently if they receive proper care. There will be no advantage in placing layers of gravel in the sand, as proposed by the plan, and this arrangement may interfere with the operation of the beds. If the proposed arrangement for flushing sewage through the distribution pipes in the first two beds out upon the ground should be used, the brook would be polluted thereby, unless some provision should be made for filtering this sewage before it enters the brook. It is important that the discharge of unpurified sewage into Sawmill Brook be avoided at all times, and the proposed flushing arrangement should not be used unless provision is made for the purification of all of the sewage.

In this, as in other sub-surface disposal systems, the pipes are likely to become clogged and require cleaning and relaying from time to time. If this shall be done when required the system can be kept in proper working order, but if a considerable increase should take place at any time in the quantity of sewage requiring purification, it will probably be necessary to enlarge the filter-beds.

MAYNARD (AMERICAN WOOLEN COMPANY).

Nov. 6, 1902.

To the American Woolen Company, MR. WILLIAM N. WOOD, *Treasurer, Maynard, Mass.*

GENTLEMEN: — The State Board of Health has considered your application for advice with reference to a proposed system of sewerage for the large number of dwelling houses recently constructed by you in Maynard, and the plans of the proposed works submitted therewith, and has caused the locality to be examined by its engineer.

The plans submitted provide for collecting the sewage from about 100 houses in a system of pipe sewers from which rain water and, so far as possible, ground drainage are to be excluded, and conveying it to a storage reservoir in the valley of a small brook near Summer Street having a capacity of 18,000 gallons, from which it is to be pumped to a filtration area located east of the County Road and north of Summer Street, about

3,000 feet from the pumping station, where it is to be purified by intermittent filtration. The effluent from the proposed filter-beds will be discharged into a small stream which flows into the Assabet River near the village of Westvale.

The capacity of the proposed works for collecting and conveying the sewage to the filtration area is, in the opinion of the Board, sufficient for the population which they are designed to serve, and they can be made to serve a somewhat larger population if found necessary in the future.

The proposed filtration area, which is located upon land owned by the company in a sparsely settled part of the town, contains soil well adapted to the purification of sewage by intermittent filtration, and the proposed filter-beds indicated upon the plans submitted with your application are, in the opinion of the Board, capable of caring for all of the sewage likely to be received from the population which the present sewers are designed to serve if the beds are properly constructed and maintained.

The proposed plan will, if carried out, provide for the efficient purification of the sewage of the new buildings of the company located in the district lying south-westerly of the intersection of Summer and Parker streets in Maynard.

NORTHBRIDGE (WHITINSVILLE).

APRIL 3, 1902.

To the Sewer Committee, Whitinsville, Mass., ARTHUR F. WHITIN, *Secretary.*

GENTLEMEN: — The State Board of Health received from you on Nov. 9, 1901, an application for advice as to a system of sewage disposal for the village of Whitinsville in the town of Northbridge, and subsequently, on March 7, 1902, a report from your engineers was received giving an outline of the proposed plans of sewerage and sewage disposal for the villages of Whitinsville and Linwood.

The plan submitted provides for a main sewer beginning near the northerly shore of Whitin's Pond, so called, at the westerly side of the village of Whitinsville, and passing south-easterly near the northerly bank of the Mumford River to the neighborhood of the village of Linwood; thence north-easterly to a filtration area on the easterly side of the New York, New Haven & Hartford Railroad a little over a mile from the village of Linwood and not far from the Blackstone River. It appears that by this plan the sewage of nearly all of Whitinsville and of a large portion of Linwood can be conveyed to the proposed filtration area by gravity. A small area in Whitinsville, including the Whitin cotton mills, is at such a low level that it will be necessary to pump the sewage from these mills and a few other buildings into the proposed main sewer, and it will also be necessary to pump the sewage from the lower portions of the village of Linwood in order to dispose of it in connection with the general system.

At the filtration area the plans provide for a settling tank in four compartments, having a total capacity of about 135,000 gallons, through which the sewage is to pass into a siphon tank having a capacity of 20,000 gallons, from which it will be discharged automatically at intervals upon the filter-beds. An automatic mechanical device is proposed, by means of which the sewage will be discharged upon the four sets of beds consecutively. Provision is made for the construction of 52 filter-beds, having an aggregate area of thirteen acres, 4 sludge beds, having an aggregate area of about half an acre, and for 13 coke strainer beds, having an aggregate area of about one acre. In the beginning it is proposed to construct the settling tank, siphon tank, three acres of filter-beds and the sludge beds, omitting the coke strainers until found necessary or desirable in the future.

The Board has caused the locality to be examined by one of its engineers and has considered the proposed plans. Examinations of the soil at the proposed filtration area show that it is suitable for the purification of sewage, and that, with properly constructed filter-beds suitably underdrained as proposed, the sewage of the villages can be effectually purified and satisfactorily disposed of at this place without difficulty for many years. The area of filters proposed in the beginning should be sufficient for the purpose, and the area can be enlarged from time to time as required.

The settling tank through which it is proposed to pass the sewage is larger than will be necessary, and, in the opinion of the Board, a tank of smaller size might be constructed in the beginning and provision made for increasing its size in the future when found necessary. A tank sufficient in size to store the sewage for a period of four or five hours would be ample, and it will be desirable to make provision so that the sewage can be discharged directly upon any of the beds if necessary without passing through the settling tank.

The proposed plan of applying the sewage to the beds intermittently will, if the proposed device works efficiently, secure an equal distribution of the sewage to the filter-beds, and in any case provision can be made for applying the sewage to the different beds intermittently, as usual in the operation of such works.

In the opinion of the Board the plan in general is an appropriate one for the collection and disposal of the sewage of Whitinsville and Linwood. While it is not practicable to take the sewage from the lowest portions of these villages into the main sewer by gravity, this sewage can be pumped into the general system without special difficulty, and there appears to be no equally satisfactory method of disposing of the sewage of these low areas.

PLYMOUTH.

AUG. 7, 1902.

To the Board of Selectmen of the Town of Plymouth.

GENTLEMEN: — The State Board of Health received from you on June 25, 1902, an application for advice relative to the disposal of the sewage of the territory in Plymouth lying between the portion of the main village now provided with sewerage and the cordage factory near the northerly boundary of the town. Plans for the sewerage of this territory which provided for the discharge of the sewage at two different outlets into the harbor in front of the town were considered by the Board last year, and the Board advised that before the sewers be constructed the whole subject of the future sewerage of the town be considered, with a view to selecting the best outlet or outlets for the sewage and avoiding the general pollution of the waters of the harbor near the thickly settled parts of the town.

The plan now proposed is intended to provide for the sewerage of the territory considered last year. By this plan the sewage from the greater part of the district will be discharged at a single outlet about 400 feet from the line of high water and about 600 feet south of Robbins wharf, near the foot of Lumber Lane. The southerly portion of the areas included in the previous plans is, by the present plan, to be made tributary to the existing system of the central portion of the town, while the northerly portions of those areas will be made tributary to an existing private sewer system put in by the cordage works.

The Board has caused the territory to be examined by its engineer and has considered the proposed plan. The new plan has the advantage over the one submitted last year that a single outlet will be provided instead of two outlets, but the single outlet now proposed is an objectionable one, since the sewage would be discharged in front of the town, where there is a large area of flats exposed at low water, and no considerable channel for the removal of the sewage.

An examination of the available information relative to the existing sewerage system, and of the contour of the lands for which it is now proposed to provide sewerage, indicates that it may be practicable to dispose of this sewage through the present main sewer outlet. It appears that a tributary to the present outlet is designed to extend along Water Street, to intercept the flow of sewage and manufacturing waste from the mill of the American Woolen Company and other buildings, which now discharges upon the beach close to a densely populated section of the town and causes a serious nuisance. A sewer designed to intercept this sewage and discharge it into the main system could, if laid at a proper grade, be extended to receive the sewage of the areas now under consideration, and thus convey this sewage to the present main sewer outlet. This outlet is situated in a favorable part of the harbor for the disposal of sewage and does not appear to cause objectionable conditions at the present time. The cost of construction of a sewer for the areas now under consideration, to connect with the present system, as indicated, would probably be but little, if any, greater than the cost of disposing of the sewage by the plan now proposed.

Considering these circumstances, the Board does not advise the construction of the sewer and outlet according to the plan now proposed, but would again advise further study, to determine the feasibility and probable cost of disposing of the sewage of the district in question in connection with the main outlet.

It is important, in designing the sewers, to make adequate provision for the sewage and to keep out storm water, and, so far as possible, ground water, since it may be found desirable to convey the sewage of the town at some future time to a more distant outlet or provide purification works.

Nov. 6, 1902.

To Mr. EDWARD B. ATWOOD, *Chairman, Board of Health, Plymouth, Mass.*

DEAR SIR: — The State Board of Health received from you on Oct. 20, 1902, an application for advice with reference to a proposed system of sewerage for certain portions of the town of Plymouth, accompanied by a plan showing the area in which it is proposed to provide sewers and the location of the proposed outlets.

One outlet is intended to provide for the territory between the district at present provided with sewers in the central portion of the town and the sewered area in the neighborhood of the cordage works, and is in general the territory considered in the previous reply of the Board, dated Sept. 5, 1901. The plan at that time provided for an outlet at low water about 600 feet south of Robbins wharf. The plan now submitted provides for the collection of the sewage in approximately the same manner, but instead of discharging the sewage in the neighborhood of the shore, where very extensive flats are exposed at low tide, the outlet of the sewer is to be carried a distance of 1,500 feet from the shore to a channel having a considerable depth of water at low tide, and through which there is a strong current on the outgoing tide leading directly toward the mouth of the harbor, while on the incoming tide the current does not set directly toward the shore, so that there is likely to be a thorough mixing of the sewage with the water before it can reach the shore.

In the opinion of the Board, the proposed outlet is a satisfactory one for the disposal of the sewage of the portion of the town which it is designed to serve.

The cost of disposing of the sewage of the district under consideration at this place is likely to be somewhat greater than the cost of discharging it into the present main sewer outlet in Plymouth harbor, but it appears that you desire to avoid concentrating any greater quantity of sewage at that place, which is in the neighborhood of the main anchorage ground in the harbor.

The plan submitted also provides for the disposal of the sewage of the district at the northerly end of the town into a sewer which now receives the sewage of the cordage works and many buildings in its neighborhood. This sewer now discharges into the harbor on the beach between high and low tide, and, when the tide is low, flows over the beach for a considerable distance before reaching the water. A bathing beach in the neighborhood is used by a considerable number of people, and this outlet under present conditions is an objectionable one.

A channel which has been dredged for boats not far from the present outlet contains at all times a considerable depth of water, and if the cordage works sewer should be extended to this channel it is likely that this outlet would be a satisfactory one until the quantity of sewage becomes much larger than would be furnished by the district tributary to this sewer at the present time.

REVERE.

SEPT. 4, 1902.

To the Special Committee on Sewerage of the Town of Revere, MR. MICHAEL SULLIVAN, *Chairman.*

GENTLEMEN: — The State Board of Health received from you on August 5 an application for advice relative to a proposed extension of the sewerage system of the town of Revere, containing the following outline of your proposed plan: —

> It is the intention to bring the sewage of practically the whole of the town of Revere (except North Revere and about 200 acres at the south-westerly corner of the town), by gravity, to a point below Young's Hill, so called, and to there build a pumping station.
>
> The sewage to be here pumped and delivered through an iron force main out to sea beyond the end of Cherry Island Bar, at a point not less than 1,000 feet beyond the end of the present sewer, or not less than 2,500 feet from high-water line.
>
> Reference may be had for further detail to the accompanying map, made by Whitman & Howard, engineers, marked "Method No. 2;" also to a copy of a report to same, on file in the office of the engineer of your Board.

You have also submitted the results of investigations, by means of floats, of the movement of the water of the sea in the neighborhood of the proposed outlet under various conditions of wind and tide.

The Board has caused the proposed outlet and its surroundings to be examined by its engineer, and has examined the plans and the results of the float experiments submitted therewith.

The results of the float experiments show that the tidal currents in the vicinity of the proposed outlet are extremely weak, and show that the movement of sewage discharged at this place would be influenced very largely by the direction of the wind, and very little by the movement of the tides. Under these conditions, floating matters discharged with the sewage would be liable, when the wind is blowing toward the shore, to be cast up on the beaches in the neighborhood.

The shores about this outlet are densely populated, and are used for bathing by very large numbers of people, the number of bathers probably being greater in the summer season in this neighborhood than at any other place on the shores of the State. Considering the results of the float experiments in connection with the other circumstances, the proposed outlet is not, in the opinion of the Board, a suitable one for the disposal in future of the sewage of the portions of the town of Revere indicated in the plan submitted.

The Board would again advise a careful investigation as to the feasibility and probable cost of disposing of the sewage of Revere into the metropolitan sewerage system, since it appears possible, from the information thus far available, that the sewage of the town can be disposed of most satisfactorily by this plan. The Board would also advise that the sewerage of the areas in the extreme north-easterly and north-westerly portions of the town be considered at the same time, so that provision can be made for the disposal of the sewage of these areas whenever it may become necessary. When you have prepared further plans for the disposal of the sewage of the town, the Board will, upon application, give you further advice in this matter.

SWAMPSCOTT.

MAY 1, 1902.

To the Sewer Commissioners of the Town of Swampscott.

GENTLEMEN: — The State Board of Health received from you on April 15, 1902, an application for the advice of the Board relative to the sewerage of Swampscott and the approval of certain plans of sewerage and sewage disposal presented in a report made by E. Worthington, civil engineer, submitted with your application.

The plans provide in general for the collection of all of the sewage of the town at a receiving basin and pumping station, to be located at the corner of Humphrey Street and Tuttle's Lane, so called, in Swampscott, whence the sewage is to be pumped to an outlet into the sea about 300 feet south of Dread Ledge, as shown on plan submitted April 28, 1902.

By the proposed plan the town is divided into four districts, known as the central section, the western section, the eastern section and the eastern pumping section. Sewage from the first three sections will flow to the receiving reservoir and pumping station by gravity. The easterly pumping section comprises an area in the north-easterly part of the town extending from the southerly end of Phillips beach to the Marblehead line, and extending about half a mile back from the seashore. The sewage of this district is to be collected at a small receiving basin and pumping station to be located near the corner of Atlantic Avenue and Beach Bluff Avenue, whence it is to be pumped into the main sewer of the eastern and central sections in Atlantic Avenue, at a point about 250 feet west of Ocean Avenue.

Profiles of the two main sewers, one for the westerly and a portion of the central sections, and the other for the easterly gravity and pumping sections, including also another portion of the central section, have been submitted with the application. Details of the proposed receiving basins and pumping stations have not been presented, excepting the statement that the main receiving basin is to have a capacity of 250,000 gallons, and to be so designed that it can be enlarged if necessary. The sewage is to be discharged through an 18-inch iron force main to the proposed outlet at Dread Ledge.

The Board has carefully considered the application and report and plans submitted therewith. The general plan of collecting the sewage of Swampscott at a central location and pumping it to an outlet into the sea at Dread Ledge is, in the opinion of the Board, the best it is practicable to adopt. The results of float experiments at Dread Ledge and the experience in the disposal of sewage into the sea indicate that sewage discharged at this outlet will not be noticeable upon any shore or beyond a limited area upon the water in the neighborhood of the outlet.

The plan of sewerage submitted appears to provide for all portions of Swampscott which require sewerage at present, and to be capable of being developed to serve all parts of the town. The two main lines of sewers — one from the easterly and the other from the westerly section through the central section to the pumping station — are adequate for the present needs, and will remove the sewage from a larger population than these areas now contain, allowing for a considerable growth of the town in the future.

The location of the proposed pumping station and receiving reservoir indicated on the plan is a suitable one, and, if the pumping station and reservoir are properly constructed, and provision made for ventilating into the chimney of the pumping station the reservoir, screen chamber and all other places from which an odor of sewage might escape, no odor of sewage need ever be noticeable in the neighborhood of the works.

The capacity of the proposed reservoir and force main is sufficient for the present requirements of the town, and, by enlarging the reservoir when necessary, these portions of the works will meet the requirements of the town for a long time in the future.

Provision should be made for screening the sewage at the pumping station; and it is desirable, in designing the reservoir, to make further provision for the retention of floating matters, if it should be found necessary or desirable to remove them from the sewage more thoroughly than can be done by screening.

The Board hereby approves the general plan of sewerage and sewage disposal for Swampscott as presented in the application and report now submitted.

TAUNTON.

JAN. 25, 1902.

To the Sewer Commissioners of the City of Taunton.

GENTLEMEN: — In response to your request for an extension of the time within which the sewage from those portions of the city of Taunton west of the Taunton River shall be disposed of upon lands in Berkley, the State Board of Health gave a public hearing in Taunton on Jan. 22, 1902, notice of the hearing having previously been published. After this hearing the Board voted to extend, for three years from July 1, 1902, the time within which the sewage from the sections of the city of Taunton indicated shall be disposed of upon lands in Berkley; so that an essential part and feature of the system of sewerage and sewage disposal of Taunton as approved by the State Board of Health is that all sewage from these sections of said city on the westerly side of the Taunton River, shown upon the map entitled "Map of a section of the city of Taunton for proposed sewerage system. Luther Dean, city engineer, 1897," filed with the petition of the sewer commissioners of the city of Taunton in 1897, shall be disposed of upon land upon the Assonet Neck Road described in the communication from said commissioners to said State Board of Health, dated June 16, 1897, on or before the first day of July, A.D. 1905.

WALTHAM.

MAY 15, 1902.

Hon. MURRAY B. CLEMENT, *Mayor, Waltham, Mass.*

SIR:— The State Board of Health has considered your application for advice relative to a proposed extension of the sewerage system of Waltham, for the purpose of protecting the public water supply of the city, and the plans submitted therewith.

The plans show the outlines of two proposed schemes for providing sewerage for low territory near the Charles River, and for the Roberts district, so called, in the westerly part of the city.

By the first plan, a sewer would be extended from the present sewer in Elm Street near Benefit Street up stream along the south bank of the Charles River and close to the edge of the river to Crescent Park, so called, thence across the river in the neighborhood of the water works pumping station by either of two possible routes and along the northerly side of the river to Roberts. This plan, according to the information furnished by you, would provide for the sewerage of all of the Roberts district and nearly all of the low area about Crescent Park, but would not provide for a small section at the southerly end of Crescent Park, and sewage from this small area would have to be pumped in order to enter the proposed sewer. Sewage from the works of the Waltham Watch Company, which is now removed by pumping, could be received into the proposed sewer by gravity. Of the two routes for crossing the river, one would pass close to the present well and pumping station of the Waltham water works, while the other, which is longer and more expensive, would cross the river farther down stream.

By the second plan, the sewage on the south side of the river would be collected in the neighborhood of the easterly side of Crescent Park and pumped into an existing sewer in Crescent Street. An outlet for the sewage of the Roberts district on the northerly side of the river would be provided when necessary under this plan by means of a sewer beginning at Prospect Street on the northerly side of the river, and extending through the cemetery and the water works reservation to Roberts; and it appears to be practicable, by laying this sewer at a grade of about 1 in 200, to collect the sewage from the districts about Roberts which seem likely to require sewerage for a long time in the future. The cost of the second plan is estimated to be $29,500.

The Board has carefully considered the plans and information submitted therewith and has caused the locality to be examined by one of its engineers. It appears that by either plan it will be possible to provide adequately for the sewerage of the districts under consideration, allowing for a large growth in population in the future.

The expense to the city of the collection and disposal of the sewage of the region in the neighborhood of Crescent Park and Roberts by gravity, as provided for in the first plan, would be much greater than the expense under the second plan, which provides for conveying the sewage from Roberts into existing sewers on the northerly side of the river and pumping the sewage from the region of Crescent Park into existing sewers on the south side of the river, even including a liberal allowance for the cost of pumping.

Considering all the circumstances, the Board is of the opinion that the most appropriate of the two suggested methods of collecting and disposing of the sewage of the Crescent Park and Roberts districts is by pumping the sewage from the region about Crescent Park into existing sewers on the south side of the river, and by collecting the sewage from Roberts when necessary into a sewer on the north side of the river to connect with existing sewers on that side.

By either of the proposed plans, the main sewer from Roberts will pass through the water works reservation and within a short distance of the well and filter gallery from which the water supply of the city is drawn. The sewer in this vicinity should be constructed of cast-iron pipe with lead joints, in order to prevent the possibility of contamination of the water supply by leakage from the sewer. Further investigations may show that it is feasible to convey the sewage from the Roberts district across the river at a point further up stream, and there discharge it into the sewers of the city of Newton; or, by the construction of a sewer along the southerly side of the river, to convey it to Crescent Park, where it can be pumped in connection with the sewage from the Crescent Park district. If the latter plan should be found, upon further investigation, to be a practicable one, it would be best to adopt it, and avoid the construction of a sewer in the neighborhood of the well and filter-gallery.

WELLESLEY.

APRIL 26, 1902.

To the Committee on Sewerage of the Town of Wellesley, JOSEPH W. PEABODY, *Chairman.*

GENTLEMEN: — The State Board of Health has considered your application for advice with reference to the sewerage of the town of Wellesley, in which you give the following outline of your proposed plan: —

> The plans herewith submitted contemplate a system of sewage collection for disposal by sand filtration.
>
> The sewage of the western or main portion of the town to be collected by gravity into a trunk sewer to be laid in Washington Street from the summit near top of "Lower Falls Hill," so called, to Abbott Road, thence in Abbott Road to the head of Fuller Brook valley, thence in Fuller Brook valley to a pumping station to be located near the Waban aqueduct bridge, at the confluence of Fuller and Waban brooks.
>
> The sewage to be pumped from this point through an iron force main laid in Dover Street, Washington Street and Blossom Street, to the filtration area indicated on map.
>
> It is planned to collect the sewage of the Lower Falls section into a receiving basin near the westerly bank of Charles River, and lift it, by use of gasolene engine, through iron force main in Washington Street over summit of Falls Hill, and discharge into trunk sewer.
>
> The "Walnut Street subdivision, Worcester Street subdivision and Upper Falls subdivision," indicated on the map, are not contemplated as needing sewers for a good many years.
>
> Sewage in these sections would have to be lifted by pumping to discharge into the main sewers of the western section.
>
> The alternative of discharging into the metropolitan sewers, provided connection therewith can be acquired, has been considered, and estimates of probable cost, together with such changes in the system of sewage collection as would be necessitated, have been compiled.

The Board has considered the plans and information submitted by your engineer, and has caused the proposed filtration area and the locations of the proposed pumping stations and other works in the town to be examined by its engineer.

The town of Wellesley is naturally divided into two portions, — one sloping easterly toward the Charles River opposite Newton, and the other sloping westerly in the valleys of Fuller and Waban brooks which discharge into the Charles River many miles above the outlets of the streams of the easterly section of the town.

The investigations show that it is feasible to collect all the sewage of the present thickly settled portions of the westerly section of the town at the proposed reservoir and pumping station, near the junction of Fuller and Waban brooks. An area in the extreme westerly part of the town, which is at present sparsely populated, is not provided for definitely in the plans submitted. Two methods for the sewerage of this area are suggested, — one by a gravity sewer in the valley of Morse's Pond and Lake Waban and thence in the valley of Waban Brook to the pumping station, and the other by pumping the sewage into the sewers of the central portion of the town. It does not appear essential, from an examination of the plans and information submitted, to select definitely at the present time a plan for the sewerage of these areas, and provision for their sewerage can safely be left for future consideration.

The plan for the sewerage of the easterly section of the town provides for collecting the sewage from nearly all of the thickly settled areas in this part of the town at a proposed reservoir and pumping station near the Charles River, near the Newton Lower Falls station on the Boston & Albany Railroad. Certain areas in the valley of Rosemary Brook, in the extreme easterly portion of the town, and in the portion of the town about the northerly end of Walnut Street, are not included in this plan; and the suggestion is made by your engineer that the sewage be pumped from these areas, when sewerage becomes necessary, into the central system. It also appears from this report that the sewage from these areas can be collected at the proposed pumping station at Lower Falls by gravity, by means of a sewer near the bank of Charles River in Wellesley; and, from an examination of the locality, it seems probable that this plan would be more satisfactory for the town, all things considered, than pumping the sewage from these areas.

The plans provide for receiving sewage only into the sewers, excluding storm water and ground water so far as possible; and in many places where sewers are to be laid below the ground-water level it is proposed to use iron pipes with lead joints, to prevent leakage of ground water into the sewers. These are important provisions, and should be carefully carried out, so that the quantity of sewage may be kept as small as possible.

The proposed filtration area is situated in a remote and sparsely populated portion of the town, and there are no dwelling houses in the immediate neighborhood of the place indicated for the filter-beds. Examinations of the soil show that it consists largely of coarse sand and gravel, well adapted for the disposal and purification of sewage; and an ample area is available here for the purpose, even though the town should continue to grow rapidly for a long time in the future.

The profiles of the proposed sewers and details of the proposed filter-beds have not been submitted, and the Board is unable to advise concerning them.

The system, as a whole, in the opinion of the Board, judging from the outlines submitted, is well adapted for the collection and disposal in a satisfactory manner of all of the sewage of Wellesley, and can be readily developed to serve all portions of the town.

The Board has considered the advisability of disposing of the sewage of Wellesley in connection with the metropolitan sewerage system; but it is evident, from the estimates of cost submitted and the other information available to the Board, that the annual cost of the disposal of all of the sewage of Wellesley into the metropolitan system will be far greater than the annual cost of disposal on land within the limits of the town, as proposed by the plans submitted. It is possible that further investigations might show that it would be of advantage to the town to dispose of the sewage of a part or all of the easterly districts into the metropolitan sewerage system.

Nov. 17, 1902.

To the Committee on Sewerage of the Town of Wellesley, Joseph W. Peabody, *Chairman*.

Gentlemen: — The State Board of Health received from you on November 6 a communication stating that since the publication of your recent report on sewerage there has been tendered to the committee a tract of land for sewerage purposes which appears to have superiority, as to location, soil, etc., over the one previously brought to the attention of this Board, and requesting that the Board cause an examination of this tract to be made and advise you as to its qualities for the purpose of the disposal of the sewage of Wellesley, and as to the relative merits of this area and the one proposed by you in your application submitted last spring.

In response to this application, the Board has caused the area indicated by you to be examined by its engineer, and has considered its suitability for the disposal of the sewage of Wellesley.

An examination of the soil in several test pits in various parts of the area now under consideration indicates that the soil beneath surface layers of loam and subsoil is a coarse and porous gravel. The area is largely cleared land, with a nearly level surface, at a sufficient elevation above the brook into which the effluent will find its way to allow for suitable underdrainage, and it is possible that the porosity of the soil is such that very few, if any, underdrains will be required.

Comparing this area with the one east of Blossom Street proposed in your plan submitted last spring, it appears that the area now proposed has the disadvantage only that it is a little farther from the pumping station, and a somewhat longer force main will be required; but, on the other hand, this area has the advantage over the one on the easterly side of Blossom Street that filter-beds can probably be constructed here at a considerably less expense, because the land is more nearly level and has a coarser and more uniform soil, so that very little underdrainage is likely to be required, probably none at all in the beginning.

In the opinion of the Board, the location is a suitable one for sewage disposal purposes, and the area which can be made available for the disposal and purification of sewage would be ample for all the requirements of the town of Wellesley.

With properly constructed sewage disposal works at this place, receiving the necessary care, no unpurified sewage would find its way into the brook, and no injury to the stream or ponds below result.

WESTFIELD.

JULY 14, 1902.

To Mr. ARTHUR S. KNEIL, *Town Solicitor, Westfield, Mass.*

DEAR SIR: — The State Board of Health received from you on June 7, 1902, an application giving notice of the intention of the town of Westfield to install a system of storm water drainage for the town, and subsequently a plan of the proposed drains was furnished by your engineer.

The plan provides for two main storm water drains, one in the valley of the brook draining the northerly portion of the main village south of the Westfield River, which is to have an outlet into the Westfield River a short distance below the present main sewer outlet, and the other in the valley of the brook which drains the southerly portion of the main village south of the Westfield River, which will have an outlet into the Westfield Little River near its mouth.

The northerly drain will take the surface water from the valley of the northerly brook, with the exception of the flow from two areas, one near the upper end of the water-shed, which is at a sufficient elevation so that the water can be carried above the top of the dike into the Westfield River at a convenient place, and the other an area near the lower end of the water-shed of the brook, which is largely farming land, and can be sufficiently drained by the natural water courses.

The southerly drain is designed to serve the entire natural water-shed of the southerly brook, excepting a section near the lower end, which, as in the former case, does not now require drainage, and can be drained sufficiently by the natural water courses. Water from the upper end of this water-shed can be diverted into the Westfield Little River if it should be found desirable to do so in the future.

The Board has caused the location of the drains and their outlets to be examined by one of its engineers, and has carefully considered the plans submitted.

It is understood that the present brooks are to be diverted into the drains at convenient points. The proposed drains are probably of sufficient capacity to carry off the water that would be likely to reach them under existing conditions; but, as the town becomes more thickly built up and the areas of street and building surfaces increase, water will find its way more rapidly and in greater quantity into the drains during storms, and may overtax their capacity.

Under the circumstances, it is advisable, in the opinion of the Board, to maintain the existing brook channels, so that, in case the drains should become surcharged, a portion of the water might flow off in the natural channels. If the channels of the brooks are to be discontinued, it will be best to provide drains of larger capacity than now proposed, to avoid danger of damage resulting from a lack of capacity in the drains.

The drains will lower the level of the ground water in the village, and, if placed at a sufficiently low level, will doubtless intercept some of the ground water which now finds its way into the sewer system, and relieve somewhat the overtaxing of the main sewer which is said to occur in the wetter portion of the year.

The growth of the town will doubtless make it necessary before many years to purify the sewage before discharging it into the river; and hence it is very important, in order to avoid unnecessary expense in the construction and operation of purifying works, that the sewage be kept separate from the storm water.

The drains now under consideration are intended for the removal of surface water and ground drainage only, and are not proper channels for sewage. It appears that there is an overflow from the main sewer into the brook on Meadow Street through which dilute sewage is discharged at times of high water in the spring; and, in the opinion of the Board, it is desirable to change this outlet so that it will discharge hereafter into the main drain, and avoid the pollution of the brook. The Board would advise that, with the exception of the overflow on Meadow Street, no connection be permitted with the proposed drains through which sewage may find its way into them. On the other hand, all connections by which storm water may enter the existing sewers should be cut off, and no further connections permitted through which storm water would be discharged into the sewers, and the entrance of ground water into the sewers should be prevented so far as possible.

WRENTHAM.

AUG. 7, 1902.

To the Board of Health of the Town of Wrentham, Mr. CHARLES W. POND, *Chairman.*

GENTLEMEN: — The State Board of Health has considered your application for advice relative to the improvement of the condition of Mann's Pond in Wrentham, a pool of stagnant water having an area at times of about a quarter of an acre, located near the central part of the village, and has caused the locality to be examined by one of its engineers.

The pond is located in a deep hollow, having no visible outlet, and receives the rain water from a small water-shed, including the street wash from the central portions of the village, and sewage and polluting drainage from buildings in its neighborhood. At times of high water the maximum depth is said to be about ten feet, and at such times it appears that the basements of buildings in the vicinity of the pond are flooded.

The soil all about the pond is apparently porous, and the height of the water is probably dependent to a considerable extent upon the general height of the ground water in its neighborhood; but it is probable also that there is impervious soil beneath the bottom of the pond, which has a tendency, especially at times of low water, to hold the water above the level of the ground water.

The pond has been a nuisance in the neighborhood, and in its present state is evidently a menace to the health of the inhabitants of the village. It would be possible to greatly improve the condition of the pond by filling it with gravel up to the ordinary summer level of the water, as suggested by your board, if, at the same time, provision should be made for keeping out all sewage and street wash; but the trouble from flooding of basements would doubtless still continue, and the cost of a thorough improvement of the pond by this plan might be larger than the cost of draining it.

The pond is located near the divide between the Charles and Taunton rivers, and it is apparently possible to drain it either in a westerly direction toward Archer's Pond or north-easterly toward a stream draining into the Taunton River. It is not possible to determine, however, without a survey, the feasibility of draining the pond to either of these places, or the probable cost of a suitable drain.

Under the circumstances, the Board would advise that, before entering upon any plan of improvement of the pond, you employ an engineer to make surveys of the most practicable routes for draining this pond, and estimates of the probable cost of the work. The elevation of the bottom of the pond at various points should also be determined, since it may be less expensive to partly fill the pond, and thus make it practicable to construct a drain at a higher level, than to drain it to the present bottom. When you have made the surveys, the Board will, upon application, give you further advice as to the improvement of the pond.

You also request advice as to draining certain meadows in the southerly part of the village, south-east of South Street. It appears from an examination of the locality that a drain formerly existed by which the water south-east of this street found an outlet across the street and thence in a south-westerly direction along the street to a stream flowing into Lake Pearl. The Board is informed that a drain has existed at this place for a long time until within a few years, and this drain was apparently sufficient to prevent the flooding complained of. The best method of preventing this flooding will be to reopen the culvert under the street, and provide a drain on the opposite side of the street to the brook referred to. If the culvert and drain are made of suitable size and at a sufficiently low level, further trouble from flooding of the district referred to can be prevented.

ICE SUPPLIES.

The following is the substance of the action of the Board during 1902 in reply to applications for advice relative to sources of ice supply: —

BOSTON.

AUG. 7, 1902.

To the Commonwealth Hygienic Ice Company, Boston, Mass.

GENTLEMEN: — In response to your request for advice as to the quality of the ice from the plant of the Commonwealth Hygienic Ice Company, the Board has caused the works to be examined and samples of the water and ice to be analyzed.

It appears from this examination that water used for the manufacture of the ice is obtained largely by condensing exhaust steam from the engines at the works, which are supplied with water from the city mains. The water is then boiled and subsequently filtered through charcoal. After cooling it is filtered again through a layer of felt, and discharged into freezing cans which are immersed in brine, and all of the water in the can is frozen.

The greater portion of the solid matter and nearly all of the albuminoid ammonia are removed by distillation; but the water, after distillation, is turbid, and has an unpleasant, oily odor, and contains a large quantity of free ammonia, the presence of the latter being due probably to the fact that the water is not completely purified by distillation, or possibly to the escape of ammonia about the plant. After filtration the water is considerably improved in quality.

The samples of the ice which have been examined have been found, upon analysis, to contain a larger quantity of organic matter than the water as discharged into the freezing cans, especially in the top of the cake and in the core; and the number of bacteria present in nearly all of the samples analyzed was much larger than has been found in the ice from other similar works. It is also found that the ice has at times a distinctly oily odor, which has been noticeable in the drinking water tanks in which this ice has been placed. The presence of the oil is doubtless due to the use of the steam in various engines about the works before it is condensed for freezing. The operation of the plant makes necessary much walking over the tops of the cans, and in this way polluting matters probably find their way into the cans, thereby increasing the quantity of organic matter in the ice.

The Board is of the opinion that it will be necessary to make several changes in the method of operating this plant, before ice of satisfactory quality can be obtained from it. It is important that the presence of oil in the ice should be wholly prevented, and this can be done by using distilled water especially prepared for the purpose. The exhaust steam now used evidently contains a quantity of oil which is not removed by the processes in use. Care should be taken to prevent the pollution of the water in the cans during the process of freezing to which they are now exposed.

There are certain disadvantages in freezing all of the water placed in the cans, because much of the impurity in the water is concentrated in the last portion of the cake frozen. These impurities would be largely excluded if a portion of the water should be allowed to remain unfrozen.

It is probable that by making the changes suggested, and allowing a small portion of the water of the cake to remain unfrozen, ice of good quality for use in drinking water can be obtained from this plant.

EASTHAMPTON.

FEB. 6, 1902.

DELOS T. PEPIN, *Easthampton, Mass.*

SIR: — In response to your application of January 17 for advice as to the quality of ice to be obtained from the "Ox Bow" on the Connecticut River just above the mouth of the Manhan River, the Board has caused the locality to be examined and samples of the water and of the ice to be analyzed. The water is evidently polluted by sewage and by organic matters which find their way into the "Ox Bow," and a sample of ice cut from this source has been found to contain much foreign matter.

The Board is of the opinion that the "Ox Bow" is not a suitable source from which to take ice for domestic purposes.

FRANKLIN.

JUNE 5, 1902.

To the Board of Health of the Town of Franklin, MR. DWIGHT M. HODGE, *Secretary*.

GENTLEMEN: — In response to your application, received May 8, requesting an investigation as to the quality of the ice taken from Boucher's ice pond in Franklin, the Board has caused the pond and its water-shed to be examined by one of its engineers, and samples of the water of this source and of ice from the ice house indicated to be analyzed.

It appears that the pond from which the ice is taken is situated in a meadow north-east of Wachusett Street in Franklin, and is connected with a brook flowing through the meadow which drains a thickly populated area in the southerly portion of the village.

The results of the examination show that the brook receives direct sewage pollution from some of the buildings on its water-shed, and that water from the brook can flow freely into the pond.

Analyses of samples of water from the pond show that it is grossly polluted by sewage; and analyses of samples of the ice taken from the ice house show that it contains a larger quantity of organic matter and a much larger number of bacteria than is found in good ice.

The Board is of the opinion that this ice cannot safely be used for domestic purposes, and would advise that the further use of the pond as a source of ice supply be discontinued.

HOLYOKE.

MARCH 6, 1902.

To the Board of Health of the City of Holyoke.

GENTLEMEN: — In response to your request for advice as to the suitability of certain ponds in the neighborhood of Holyoke as sources of ice supply, the Board has caused the following sources indicated by you to be examined and samples of the water and ice to be analyzed: —

A pond on Jacob's Hollow Brook in South Hadley.

The Chicopee River above Chicopee Falls.

A pond on Darby Brook just above Riverdale Road.

A pond on Tannery Brook near Riverdale Road and near the boundary between Holyoke and West Springfield.

A pond on Tannery Brook near the Holyoke & Westfield Railroad in the westerly part of Holyoke.

A pond on stream west of city almshouse.

The pond on Jacob's Hollow Brook is a new one, and appears to be free from serious danger of sewage pollution, and, in the opinion of the Board, ice taken from this pond may be safely used for domestic purposes.

Analyses of samples of ice cut from a pond on the Chicopee River above Chicopee Falls last year showed the presence of a considerable quantity of organic matter, and the Board advised that the ice cut from this pond should not be used where it might come in contact with food or drinking water. Examinations of additional samples of ice cut from this source during the present winter give results similar to those obtained last year, and the Board sees no reason for modifying the advice that ice cut from this source should not be used where it may come in contact with food or drinking water.

The pond on Darby Brook just below the Riverdale Road receives considerable direct sewage pollution, and the ice contains considerable organic matter, even in the clear ice beneath the snow ice. In the opinion of the Board, it is not desirable to use ice from this source for domestic purposes.

The pond on Tannery Brook just above the Riverdale Road has quite a large water-shed, and receives a portion of the sewage from a large institution about a quarter of a mile above the place from which the ice is cut. This ice, like that of the previous sample, was made up partly of snow ice, but the clear ice also contained considerable organic matter. In the opinion of the Board, it is not desirable to use ice from this source for domestic purposes while sewage is discharged directly into the brook. If the sewage discharged into the stream above the ice pond from the institution referred to should be prevented from entering the brook, it is probable that ice of much better quality could be obtained from this source.

The pond on Tannery Brook above the Holyoke & Westfield Railroad is formed by flooding a meadow, and is apparently quite shallow over a considerable portion of its area. The water-shed contains a few farm-houses, but the stream does not appear to be exposed to serious pollution excepting possibly from manure spread upon the cultivated lands. The results of an analysis of a sample of ice from this source show that the clear ice is of good quality. It is important, however, in using ice from this source, as well as from other ponds with similar water-sheds, that the first inch of ice that forms upon the pond be removed when the ice is harvested, including all snow ice or ice which may form by rain or flooding above this first inch, and that only the clear ice formed beneath the first inch be retained for use. It is important also that the ice be cut where the water has a considerable depth, and that no ice be used containing weeds or other organic matter taken up from the bottom of the pond.

An examination has also been made of the water of the stream west of the city almshouse; but the dam by which the ice pond was formed has been carried away, and it is not practicable to obtain a sample of ice at the present time. It is understood that no ice will be cut from this source during the present winter.

MARBLEHEAD.

SEPT. 4, 1902.

To the Board of Health of the Town of Marblehead, Mr. FRANK W. GOODWIN, *Secretary.*

GENTLEMEN: — In response to your request of Aug. 16, 1902, for advice as to the best practicable method of protecting the purity of an ice supply on the estate of B. W. Crowninshield in Marblehead, from which ice for public sale has been taken in the past, the Board has caused the source of supply and its surroundings to be examined by one of its engineers.

It appears from this examination that the ice pond is a shallow one which is flooded only in winter, and that the bottom is covered with a vegetable growth during the summer season. The principal sources of pollution at the present time are a gelatine factory, which has a waste pipe discharging into the stream which feeds the pond, a piggery located near this stream, and deposits of night soil used to fertilize the lands in the water-shed. It is understood that the number of pigs to be kept hereafter in the piggery will be very greatly reduced, and, if these and the drainage from them are kept from access to the streams draining into the ice pond, danger of serious pollution from this source will be prevented. If the discharge from the gelatine factory can be removed from the water-shed of the pond or efficiently purified, and the disposal of night soil within the water-shed prevented, this pond can be made a suitable source of ice supply. It will be necessary, however, that all vegetation be removed from the bottom of the pond before flooding in the early winter, to avoid danger that organic matters may be taken up by the ice; and no ice containing foreign matters should be used, and this will exclude all ice formed in the shallow water near the shores.

NEW BEDFORD.

FEB. 6, 1902.

To the Board of Health of the City of New Bedford.

GENTLEMEN: — The State Board of Health, in response to your request of January 24 for advice as to the use of ice from Russell's Pond for domestic purposes, has caused the pond and its surroundings to be examined and samples of the water and ice to be analyzed. The examination shows that the water-shed of the pond contains many houses and other buildings, and it is possible that polluting matters may at times find their way into the pond. It appears also that the pond is quite shallow over a considerable portion of its area.

The only way in which it is possible to obtain ice from this pond which may be safely used for domestic purposes will be to remove from the ice the first inch of ice that formed upon the pond, and all snow ice or other ice formed by rain or flooding above this first inch, and to retain for use only the clear ice beneath the first inch which forms. It is also important that ice be harvested only from those portions of the pond where there is a depth of a foot or more of water between the ice and the bottom of the pond, and that no ice containing weeds or other foreign substances be used. If these conditions are carefully observed, it is likely that ice which may safely be used for domestic purposes can be obtained from this source under present conditions.

POLLUTION OF PONDS, STREAMS AND OTHER BODIES OF WATER.

The following is the substance of the action of the Board during 1902 in reply to applications for advice relative to the pollution of ponds, streams and other bodies of water: —

AGAWAM.

JULY 3, 1902.

MR. HENRY E. BODURTHA, *Chairman of Board of Selectmen, Agawam, Mass.*

DEAR SIR: — The State Board of Health has considered your application for advice as to the use of a storm water drain in Main and Lane streets as a public sewer, and has caused the locality to be examined by one of its engineers.

The drain in question discharges into a ditch on the southerly side of Lane Street, in which there is little or no flow during the summer season; and, while this is a suitable outlet for storm water, the discharge of sewage at this place would create objectionable conditions. The Board would advise that no connections be allowed for the discharge of sewage into this drain.

The Board has also considered the conditions caused by the discharge of mill wastes from the woolen mill of the Agawam Company into the

Three Mile River, as requested in your application, and has caused the locality to be examined. At the present time the pollution of the stream is caused by the discharge of spent dyes, the principal effect of which appears to be the discoloration of the water. A considerable relief could doubtless be obtained for the present if an arrangement could be made so that the spent dyes would be discharged only at times when the wheels are running, or when there is a considerable flow of water in the stream below the mill.

It is very important, in the opinion of the Board, to prevent the pollution of the Three Mile River and the streams and waters about the village by sewage or manufacturing refuse; and the Board would advise that a plan be prepared for the proper disposal of the sewage of the village and the wastes from the mill. Such portions of the plan as might be required from time to time could then be built, and the pollution of the waters about the village prevented.

Charles River Dam Committee.

Jan. 23, 1902.

To Henry S. Pritchett, *Chairman of the Committee on the Charles River Dam.*

Sir: — The public work of the State Board of Health, so far as it relates to the proposed dam in Charles River, is the work required in relation to the general oversight and care of inland waters under the provisions of the Public Statutes, and the work upon the examination of sewer outlets and the effect of sewage disposal under the provisions of chapter 104 of the Acts of 1901.

The proposed dam, it is assumed, would be located a short distance above Craigie's bridge, between Boston and Cambridge, and would raise the water to a constant level about 8 feet above the Boston city base. The information collected refers to the quantity of sewage discharged into the river and its tributaries above the dam, and the relation of this quantity to the flow of the stream after the dam shall be built, and the effect of such discharge upon the sanitary condition of the river.

The Charles River, above the proposed dam, drains an area of about 306 square miles. Near Dedham there is a channel leading from Charles River into the Neponset River, which is known as Mother Brook, and it has been decided by the courts that Mother Brook is entitled to one-third of the water of the Charles River at the point of diversion. Taking out one-third of the drainage area above Mother Brook, the total water-shed of the river at the proposed dam is approximately 239 square miles.

The upper portion of the Charles River water-shed is, for the most part, sparsely populated. At Milford, near the extreme upper end of the watershed, there are two sewer outlets discharging into the river the sewage from about 600 people. At Milford, Franklin and Medway, manufacturing wastes are discharged into the stream from factories and mills at several places; but, so far as known, there are no other sewer outlets into this stream between those at Milford and the proposed basin, a distance of about 56 miles along the river, and the river above the latter point is more free from direct sewage pollution than any other of equal size in the eastern part of the State.

The sewage from Cambridge, on the northerly side of the proposed basin, is collected into a branch of the north metropolitan sewerage system, which discharges at Deer Island. The sewage from Waltham and Watertown, on the northerly side of the river above Cambridge, and the sewage of Newton, Brighton, Brookline and the Back Bay district of Boston, together with sewage from the westerly side of the city proper bordering on the Charles River and from the valley of Stony Brook, one of its tributaries, find an outlet through the main drainage system of the city of Boston at Moon Island.

The sewers of Waltham, Watertown and Newton are constructed upon the separate plan, storm water being kept separate from the sewage. In Brighton, Brookline and Boston the sewers are constructed largely on the combined plan, and receive both sewage and rain water. When the main drainage and metropolitan sewers were built, and intercepted the local sewers, valves were placed at the connections with the intercepting sewers whereby the flow of local sewers at times of storms is largely shut off from the intercepting sewers, and discharges through the former outlets; and in the district bordering Charles River these outlets discharge into the river or its tributaries.

Since the Boston main drainage system was constructed a much larger area has been connected with it than was originally planned; and the quantity of rainfall that can be received from the districts having combined sewers as a whole is much smaller at present than is provided for in the original plan.

On the north side of the river in Cambridge the sewers were constructed upon the combined plan originally, and sewage and storm water were received into the sewers. At the connections with the local sewers valves are placed similar to those on the Boston side of the river, by which the excess of flow at times of storms is discharged through original outlets into Charles River.

Sewers on the separate system are now being built in Cambridge which are connected directly with the metropolitan sewer, without shut-off valves; and, in connection with the separation of the sewage from the storm water, sewers have been built for storm water only, which discharge directly into the river. The capacity of the Cambridge branch of the metropolitan sewer for receiving storm water is much greater than the capacity of the metropolitan and Boston main drainage sewers south of the river; and the quantity of mingled sewage and storm water discharged into the river is less in Cambridge in proportion to the area than in Boston.

The total number of storm overflow outlets from the metropolitan sewers into the Charles River above the proposed dam is about 30. There are also 25 overflows, so far as known, from sewers in the valley of Stony Brook, from which mingled sewage and storm water may be discharged into that stream at times of storms.

The calculated quantity of sewage discharged into the river and Stony Brook from these various overflows is equivalent, at the present time, in a dry season at the time when the flow of the river would be lowest, to the sewage of about 4,300 people, discharging continuously; but this sewage does not, as a matter of fact, discharge continuously, but at irregular intervals during rains at many outlets all along the shores of the basin and along Stony Brook, a condition favorable for a thorough dilution. To this should be added the sewage of about 1,000 persons in houses along Beacon Street in the Back Bay district of Boston, which are said to have independent outlets into the river.

The Boston main drainage system receives at the present time the sewage from a very much larger area than that for which it was originally designed; and a new main intercepting sewer, known as the high-level sewer, is now being constructed from the Back Bay district of Boston in a generally south-easterly direction across Boston and Quincy to an outlet near Nut Island. This sewer is designed to take the flow of sewage from the Charles River valley metropolitan sewer and areas in the Back Bay district of Boston, together with the sewage of portions of Dorchester, Roxbury and West Roxbury, which now flows into the Boston main drainage system, and to convey it, with other sewage, to the new outlet near Nut Island. This sewer, which is of very large size, will, when completed, receive all of the sewage of the Charles River valley metropolitan sewer, with additions from some of the Back Bay districts, and of a large portion of the Stony Brook valley, and it will provide for removing many times the quantity of storm water which can now be received into the Boston main drainage system; at the same time, by relieving the Boston main drainage system of the flow of the Charles River valley and other sewers, the completion of the high-level system will greatly increase the capacity of the Boston main drainage system for removing storm water.

After the high-level sewer is built, probably within two years, it is calculated that the quantity of sewage that will discharge through the storm overflows, in a dry season when its dilution by the flow of the river would be the least, would be equivalent to the sewage of about 2,400 people, and, adding the population in houses along Beacon Street, to 3,400 people, discharging sewage all the time; but this discharge, as already indicated, will take place during rains at irregular intervals and at numerous outlets all about the basin.

Comparing the quantity of sewage that would be furnished by 3,400 people with the estimated flow of the river for the three driest consecutive months that have occurred within the last twenty-seven years, the dilution by the flow of the river alone would be far greater than the amount which is regarded as essential for the prevention of objectionable conditions under such circumstances.

The condition indicated herein which will exist when the high-level sewer system is completed will doubtless be modified by future growth of population and changes in the systems of sewerage. If nothing further should be done to prevent sewage entering the river or its tributaries through storm overflows after the construction of the high-level sewer, it is unlikely that the increase in the quantity of sewage discharged into the basin through such overflows would produce objectionable conditions. A material enlargement of the area served by combined systems of sewers is impossible under existing laws, and the work of separating the sewage from the storm water in areas already provided with sewers upon the combined plan has been undertaken within the district tributary to the basin; and a reduction in the quantity of sewage entering the basin and its tributaries through storm overflows will gradually come about if this policy is adhered to, — and the sanitary interests of the district require that it should be adhered to.

A considerable fraction of the present pollution of the river can be prevented by constructing an intercepting sewer which shall take the sewage from the Beacon Street houses, now discharging directly into the river, into the high-level system. This being done, the amount of sewage entering through the storm overflows at present or likely to enter at any future time would be so small, compared with the flow of water in the river, that it could not be regarded as a menace to the health of those boating upon the basin or living upon its borders.

COHASSET.

MAY 1, 1902.

To THOMAS MANNIX, *Chairman of the Committee on Cemetery*, *Cohasset*, *Mass.*

SIR: — The State Board of Health has considered your application for advice as to whether or not the placing of a cemetery on the southerly side of North Main Street in Cohasset west of Sohier Street and north of the New York, New Haven & Hartford Railroad would injure the water supply of the town, and has considered the results of investigations as to the movement of ground waters in this territory.

It appears from the results of examinations of this territory several years ago by means of test wells, with a view to the use of ground water from lands along the railroad west of Sohier Street for the supply of Cohasset, that the ground water of this region is affected by pumping from the present wells of the Cohasset Water Company; and, in the opinion of the Board, if the lands indicated in your application should be used as a cemetery, the water entering the wells of the Cohasset Water Company would be injuriously affected thereby.

HARWICH (WYCHMERE HARBOR).

OCT. 2, 1902.

To the Board of Health of the Town of Harwich, Mr. AMBROSE N. DOANE, *Chairman.*

GENTLEMEN: — The State Board of Health received from you on Sept. 18, 1901, a communication relative to offensive odors caused by seaweed collecting along the shore on the westerly side of the jetty at Harwichport, and requesting that the State Board of Health examine the locality and advise you as to the removal of the objectionable conditions complained of. Subsequently, on May 13, 1902, a second communication was received from your board, stating that the waters of Wychmere Pond at Harwichport had suddenly become polluted, and requesting this Board to examine the conditions prevailing there, and advise your board as to the proper course to pursue in order to abate the nuisance.

In response to these applications, the Board caused Wychmere Harbor and the seashore at Harwichport to be examined at different times during the past summer by its engineers; but no offensive odors were noticeable at these times, and there was no evidence of serious pollution of the waters of Wychmere Harbor. The deposit of seaweed in the harbor does not appear to be increasing at present, and is not exposed at low water, excepting possibly at one or two points, and, unless disturbed, is not noticeably offensive. The harbor receives sewage from neighboring buildings at two or three places, but the quantity is so small that its effect upon the water is not noticeable.

A communication from your board, received on September 12, states that no objectionable odors have been noticed since the last examination was made, in midsummer, and that you consider further investigation unnecessary. This Board will, therefore, take no further action in the matter.

HUDSON.

OCT. 2, 1902.

To the Board of Health of the Town of Hudson, Mr. NATHAN RUSSELL, *Secretary.*

GENTLEMEN: — The State Board of Health has considered your application for an examination of the condition of Clye Brook in the town of Hudson, and advice as to the sources of the pollution of the stream, and has caused the locality to be examined by one of its engineers and samples of the water to be analyzed.

It appears that Clye Brook is a small stream flowing from the vicinity of the rubber factory through a thickly built-up portion of the town to a large mill pond, known as Bruce's mill pond. Sewage and wastes from the rubber factory at the upper end of the stream are discharged directly into it, and it receives also, directly and indirectly, the sewage from a large number of dwelling houses below the rubber factory. The water flowing in the brook has the appearance of sewage and has an offensive odor.

The results of analyses of samples of water from the brook show that the evidences of sewage pollution are greater at the upper end near the rubber factory than at the lower end; but, even if the sewage and wastes from the rubber factory should be diverted from the brook, it is probable that its condition would still be offensive, on account of the sewage discharged from buildings farther down the stream.

In the opinion of the Board, the best method of improving the condition of Clye Brook is to construct a sewer in this valley to receive the sewage of the rubber factory and of the houses now draining directly or indirectly into the stream, and remove it to some suitable place of disposal.

It appears from examinations made by the Board that sewerage is required in other portions of the town, and that at some places sewage is discharged into drains intended for storm water, — a very objectionable method of providing sewerage, which, if continued, is liable to cause the town much trouble and expense in the future.

The Board would advise that any sewers or other works constructed for the removal of sewage from Clye Brook, or other places in the town which require sewerage, be so located and constructed that they may form a part of a general system for the village in the future. The Board would also advise that surface water and ground water be kept out of the sewers, since surface water and ground drainage can, if not mingled with sewage, be allowed to discharge into local water courses without offence. The quantity of sewage to be disposed of by the town will in this way be kept much smaller than would otherwise be the case, and the cost of disposing of it greatly reduced.

MANCHESTER.

AUG. 7, 1902.

To the Water Commissioners of the Town of Manchester, Mr. N. P. MELDRAM, *Chairman.*

GENTLEMEN: — The State Board of Health received from you on July 25, 1902, a request for advice relative to the protection of the water supply of Manchester from pollution by the disposal of night soil and garbage at certain places within the water-shed of Saw Mill Brook, in the valley of which the wells from which your water supply is now drawn are situated, and has caused the localities indicated to be examined by one of its engineers.

It appears from the information furnished by you that night soil has been deposited near the southerly side of Leach Mount, so called, in the valley of one of the main branches of Saw Mill Brook, and also at a place in the valley of the brook, about 1,000 feet west of the wells from which the water supply is drawn.

An examination was also made, at your request, of a piggery located on the westerly side of the main road from Manchester to Essex, a short distance south of one of the main tributaries of Saw Mill Brook, which is a place of disposal for garbage collected in Manchester.

There is no doubt that Saw Mill Brook has been polluted by the disposal of night soil near Leach Mount in the westerly part of its water-shed; and it is evident, from an examination of the surroundings of the piggery, that much polluting matter from this place also finds its way into the stream.

The deposit of night soil at the place about 1,000 feet west of the wells in the lower part of the water-shed of Saw Mill Brook is so located that the surface drainage from this place probably enters the brook below the wells; but it is evident, from the character of the soil, that the liquid portion of the material deposited at this place will find its way readily into the ground, the soil being porous, and may, in this way, affect the quality of the water of your wells. It is not practicable, however, to determine from a superficial examination of the ground whether any of the ground water from this neighborhood enters the wells, and in order to determine this it would be necessary to make a careful observation by means of test wells upon the movement of the ground water.

In the opinion of the Board, it is very important that the pollution of the water of Saw Mill Brook above the wells should be prevented, since it is probable that part of the water which enters the wells from which the water supply of Manchester is drawn is derived from the brook by filtration through the ground. It is especially important to prevent the deposit of polluting matters upon the ground at any place from which ground water may drain toward the wells; and, while the deposit of night soil at the place about 1,000 feet west of the wells may not at present affect the quality of the water, safety requires that the use of a place so near the wells for this purpose should be discontinued.

The Board would advise that the town provide some proper means for the disposal of garbage and night soil, whereby the danger of the pollution of the water supply of the town shall be avoided.

MATTAPAN IMPROVEMENT ASSOCIATION (NEPONSET RIVER).

MAY 23, 1902.

To the Mattapan Improvement Association, JOHN E. SAVAGE, *Clerk.*

GENTLEMEN: — The State Board of Health has considered your application for information relative to the condition of the Neponset River, as compared with the conditions existing in this valley five years ago, when a special report upon this stream was made by this Board to the Legislature.

No thorough examination of the Neponset River, such as would be required in order to obtain the data necessary to answer fully the question presented in your application, has been made by the Board since 1897, the year in which the special report referred to was presented to the Legislature; and the Board is, therefore, unable to advise you definitely as to the changes which have taken place since that time, or the condition of the river and meadows as compared with their condition at the time the special report was made.

Judging from such chemical analyses of the water of the river as have been made in the years since 1897, and such other data as is available, the Board is of the opinion that the conditions in this valley have continued to grow worse since the special investigation of 1897.

NORTHBOROUGH.

OCT. 2, 1902.

To the Board of Selectmen and Other Citizens of the Town of Northborough.

GENTLEMEN: — The State Board of Health received from you on August 27 a petition protesting against the disposal of the sewage of the Lyman School for Boys into the Westborough sewage beds, and stating that the imperfectly purified effluent from these beds goes into the Assabet River.

It appears that the disposal of the sewage of the Lyman and Industrial Schools into the Westborough sewerage system was authorized by the provisions of chapter 90 of the Resolves of 1902, and the Board is informed that works for the disposal of the sewage of the Lyman and Industrial Schools, under the provisions of the above resolve, are now under construction.

In response to your petition the Board has caused the Assabet River to be examined by its engineer and has carefully considered the results of the operation of the Westborough sewage disposal works and the condition of the Assabet River below the filter-beds, as shown by numerous analyses of samples of effluent from the filter-beds and of samples of the river water collected at frequent intervals during several years at a point about 1,000 feet below the filter-beds.

These results show that previous to the reconstruction of the outfall sewer and filter-beds in 1899 both crude and imperfectly purified sewage were discharged from the Westborough filter-beds into the Assabet River, but that since the outfall sewer and filter-beds were built by the town of Westborough in 1899 the filter-beds have been of ample capacity for the thorough purification of all the sewage of the town.

Recent examinations of the filter-beds and analyses of the effluent therefrom show that, owing to lack of proper care in the maintenance and operation of the filters, the sewage was not being purified as thoroughly by these works as would be practicable if they should be properly operated, and this Board so notifies the sewer commissioners of Westborough.

The results of recent chemical examinations of the water of the river show, however, that this stream is very slightly polluted at the present time by the effluent of the Westborough filter-beds, and, in the opinion of the Board, the condition of this stream in Northborough is not at present liable to affect unfavorably the health of those living in its neighborhood.

While the disposal of the sewage of the Lyman and Industrial Schools into the Westborough sewerage system will increase considerably the quantity of sewage to be disposed of at the Westborough filter-beds, these beds are, in the opinion of the Board, of sufficient capacity to purify satisfactorily all of the sewage likely to be conveyed to them, for the present at least, including that which will be contributed by the Lyman and Industrial Schools, in such a manner that the effluent will not have an effect upon the Assabet River unfavorable to the health of those living upon its banks, and the Westborough filter-beds can be enlarged in the future without special difficulty.

WALTHAM.

JULY 3, 1902.

To the Board of Health of the City of Waltham.

GENTLEMEN: — The State Board of Health received from you on Oct. 13, 1900, an application for advice as to the probable effect of the use for burial purposes of a part of the Mt. Feake cemetery hitherto unused which lies near the water works reservation; and since that time, with the assistance of the water works authorities, observations have been made by the Board for several months upon the height of water in various test pits along the edge of the cemetery in the neighborhood of the water works pumping station, and many samples of water from the well from which the supply is drawn have been analyzed.

The results of all the observations show that ground water from portions of the Mt. Feake cemetery north-east of the present well, in which many interments have already been made, is finding its way into the well.

The area of land which it is now proposed to further develop within the cemetery is not so near the well as areas already developed, but the observations show that it is, nevertheless, probably within the area from which the ground water at present flows toward the well.

The results of analyses of water from the well have shown for several years that the water passing through the ground into the well is being polluted; and there has been a deterioration in the quality of the water drawn from the well, owing to an increase in the quantity of iron, though the quantity of iron present in the water has not yet become so great as to noticeably affect its quality. The increase in the quantity of iron is doubtless due to the passage of imperfectly filtered water into the well from Charles River, and in part to pollution of the ground waters tributary to the well.

In a communication to the mayor of Waltham in 1897 the Board suggested, as possible remedies for the deterioration in the water, that all sewage be removed from the territory supplying water to the filter basin; that the draft from the basin be diminished so that it should not exceed the amount drawn from the basin before the quantity of iron began to increase; and that another source be secured for the additional water required for the city.

It does not appear that sewers have yet been extended into the territory near the wells which required sewerage at that time, though plans for the sewerage of this territory have now been prepared. The quantity of water used by the city in 1901, moreover, was 50 per cent. greater than in 1897 and more than twice as great as at the time the quantity of iron in the water began to increase. Under the circumstances, it is likely that the quality of the water will continue to deteriorate.

There is no doubt, in the opinion of the Board, that the use of the lands in the south-westerly part of Mt. Feake cemetery bordering Charles River for cemetery purposes under present conditions affects unfavorably the quality of the water of the well, and the use of the area indicated for development will have a further unfavorable effect upon the quality of the water. Under these circumstances, it is desirable, in the opinion of the Board, to prevent the development of the portions of the lands in the cemetery indicated in your application, and the further use of other sections that are within 1,000 feet of the wells.

WESTBOROUGH.

JUNE 5, 1902.

To the Board of Health of the Town of Westborough.

GENTLEMEN: — The State Board of Health received from you on April 23, 1902, a communication stating that sewage from some of the buildings of the Lyman and Industrial Schools was overflowing upon the grounds near the buildings and finding its way into the highway, and requesting this Board to suggest a remedy for the nuisance thereby created.

In response to this request, the Board has caused the locality to be examined by one of its engineers, and finds that the conditions now existing are about the same as those which were found to exist at the time of a previous examination by this Board in the latter part of 1899, and that unpurified sewage from some of the buildings is discharged upon the ground and finds its way into the highways and water courses.

On Oct. 5, 1899, the Board advised the trustees of the Lyman and Industrial Schools to employ an engineer of experience in matters relating to sewage disposal to investigate the feasibility and probable cost of disposing of the sewage in connection with the system of the town of Westborough, or upon some filtration area independent of the town system.

It appears that the trustees have employed an engineer, as advised, and caused investigations to be made as to the disposal of the sewage of the school; and that, since your communication was received, a resolve has been passed by the General Court (chapter 90, Resolves of 1902), authorizing a contract for the disposal of the sewage of the Lyman and Industrial Schools by means of a connection with the trunk sewer of the town of Westborough, and providing an appropriation therefor.

In view of these circumstances, it appears to the Board unnecessary for the town to take further action in the matter at present, except to hasten as much as possible the construction of works for disposing of this sewage by a connection with the sewerage system of the town of Westborough.

OCT. 2, 1902.

To the Sewer Commissioners of the Town of Westborough.

GENTLEMEN: — In response to a petition from the town of Northborough relative to the discharge of imperfectly purified sewage from the Westborough filter-beds into the Assabet River, this Board has caused the condition of the Westborough filter-beds and the method of their operation to be examined by its engineer.

It appears from this examination and measurements of the flow of sewage that the filter-beds are of ample capacity for the efficient purification of all of the sewage of the town of Westborough at the present time, including the sewage likely to be received from the Lyman and Industrial Schools.

At the time the beds were visited, on September 5 and 9, all of the sewage was flowing upon one of the beds, and covered only about one-fifth of the area of this bed. Sewage had evidently been disposed of in this way for several days at least; and a sample of the effluent collected subsequently while these conditions still continued showed that the effluent flowing from the bed was of much poorer quality than these beds are capable of producing when properly operated. In order to secure satisfactory purification of the sewage of Westborough, it is necessary, in the opinion of the Board, that the beds should be levelled, so as to secure an even distribution of the sewage, and that the sewage should then be discharged upon them intermittently at frequent intervals, and not allowed to run for several days upon a single bed or a portion of a bed, as is now the case.

WEST SPRINGFIELD.

SEPT. 4, 1902.

To the Board of Health of the Town of West Springfield, Mr. S. A. BRAGG, *Agent.*

GENTLEMEN: — The State Board of Health received from you on July 28 an application requesting an examination of certain possible sources of pollution in the water-shed of Bagg Brook, used as a source of water supply by the town of West Springfield, and has caused the localities indicated by you to be examined by one of its engineers.

It appears that the town of West Springfield draws water from Bagg Brook and pumps it directly into the street mains of the town. The sources of pollution referred to in the application are near the upper end of the south-west branch of the stream, about three-quarters of a mile from the point where the water is taken. At this place there is a group of farm buildings from which polluting drainage evidently finds its way into the brook. In the opinion of the Board, the health of those who use water from Bagg Brook is endangered by pollution of the water at this place; and the Board would advise that, if the use of this source of water supply is to be continued, the pollution of the water from the farm buildings be prevented.

Bagg Brook drains a cultivated territory, and there is danger of the pollution of the brook by material used to fertilize the lands within its water-shed. Danger of the pollution of the water from this cause also should be prevented, if the use of the brook as a source of water supply is to continue.

WEYMOUTH (WHITMAN'S POND).

DEC. 20, 1902.

To Mr. EDWARD J. PARKER, *Quincy, Mass.*

DEAR SIR: — The State Board of Health received from you on August 27 a communication relative to the condition of Whitman's Pond in Weymouth, and has caused the pond and its surroundings to be examined by its engineer, and collected information as to cases of malarial sickness in the neighborhood of the pond.

As a result of the investigation made by the Board, it appears that there has been a considerable number of cases of malarial disease in recent years in the northerly part of Weymouth, and some cases near the pond. Whether these cases may have been caused by any condition existing in the pond cannot be stated with the information now available to the Board.

At the time the pond was examined, its bottom was exposed over a very large part of its area. In most places it appeared to be clean and dry, but in some places there were pools of standing water, and other conditions which may perhaps require improvement.

The Board will make a further examination of the cases of malarial sickness in Weymouth during the next warm season, and will then advise you as to the information obtained, and take such action as may be necessary in the matter.

RULES AND REGULATIONS FOR THE PURPOSE OF PREVENTING THE POLLUTION AND SECURING THE SANITARY PROTECTION OF SOURCES OF WATER SUPPLY, IN COMPLIANCE WITH REQUESTS FROM THE AUTHORITIES OF CITIES AND TOWNS UNDER THE PROVISIONS OF CHAPTER 75, SECTION 113, OF THE REVISED LAWS.

Under the provisions of section 113 of chapter 75 of the Revised Laws, authorizing the State Board of Health to make rules and regulations for preventing the pollution and securing the sanitary protection of sources of water supply, rules and regulations were made for the protection of Cape Pond in Rockport, used as a source of water supply for that town, and for the protection of Elder's and Assawompsett ponds in Lakeville and Middleborough, used as sources of water supply for the city of Taunton.

Public Institutions (Chapter 75, Revised Laws, Section 4).

Worcester Insane Asylum. A request was received from the trustees of the Worcester Insane Asylum for the approval by the State Board of Health of a tract of land lying in Grafton, Westborough and Shrewsbury, as a location for farming and colony purposes in connection with the asylum. The proposed tract contains about 500 acres, and is partly in the water-shed of the Assabet River and partly within that of the Quinsigamond River. The Board approved the location Aug. 7, 1902.

EXAMINATION OF WATER SUPPLIES.

EXAMINATION OF WATER SUPPLIES.

EXPLANATORY NOTE.

The systematic examination of the water supplies of Massachusetts was begun by the State Board of Health, June 1, 1887, and has been continued up to the present time. The results of the investigations which were made during the first two years were published in the special report of the Board upon the Examination of Water Supplies (1890), and the results of the examinations made in succeeding years have been published in the annual reports of the Board, beginning with the twenty-second (1890).

The special report upon the Examination of Water Supplies (1890) contains descriptions of each of the public water supplies in the State existing at the time of that report, and the results of chemical and microscopical examinations of samples of water collected from the principal sources of supply. The annual reports beginning with the report for the year 1890 contain descriptions of all new works and the important changes in existing works, together with the results of the chemical and microscopical examinations which have been made of the various sources of supply. In the annual report for the year 1898 a brief description of the source of supply was given in cases where a knowledge of the conditions and surroundings of the source would assist materially in understanding and interpreting the analyses.

In the reports previous to 1901 the results of practically all of the analyses which have been made of the various sources of supply have been presented in full; in the report for the year 1901 the results of the individual analyses were omitted in most cases, and only the average of the analyses made during the year was given, and this plan has been followed in the present report. In a few cases in which the analyses made during the year are of special interest from some cause, or in which there has been a marked change in the character of the water during the year, the analyses of all of the samples collected during the year are given in full. Wherever analyses have been made regularly in previous years, the mean of the averages of previous years is given for comparison; but in some cases where there has been a change from year to year in the character of the water, the average analysis for each previous year is given in the tables.

Microscopical examinations have been made of nearly all of the samples from surface water sources which have been examined chemically; but the results of these examinations are omitted from this report, except in cases where certain organisms which are known to have given trouble in water supplies have been found in considerable numbers.

In this report, as in former reports, an alphabetical arrangement by towns has been adopted in presenting the analyses of all sources of water supply, the source being tabulated under the name of the town supplied, except that the analyses of the sources used for the supply of the metropolitan water district are placed at the beginning. The analyses of samples collected from rivers not used directly as sources of water supply are given in a subsequent chapter.

The method of making chemical examinations has not been changed during the past year. All surface waters and such samples of ground water as contain suspended matter are filtered through filter paper before determining the color, residue on evaporation, albuminoid ammonia in solution and oxygen consumed. Some ground waters which are practically clear and colorless when drawn from the ground become turbid on standing, in consequence of the oxidation of the iron which they contain; in these waters the residue on evaporation is determined without filtration.

The color of the water is expressed by numbers, which increase with the amount of color. The standards used are natural waters, the color of which has been accurately determined by comparing them with the nesslerized ammonia standards which were described on page 531 of the special report on the Examination of Water Supplies (1890), and on page 329 of the annual report for 1892. By using natural waters as standards of comparison, an apparent rather than an actual color is obtained, as a natural water nearly always has a greater or less degree of turbidity, which gives the water an appearance of having a greater color than it would have if there were no turbidity.

The rainfall during the year 1902 has been about normal. The greatest excesses occurred in February and December, and the greatest deficiencies in January, May and November.

The flow of streams, as indicated by the Sudbury River records, has been slightly greater than the normal, although during nine months of the year the flow was less than the normal for those months. The months in which an excess occurred were January, March and December. There was a considerable deficiency in the flow during the months of July, August and September.

Tables showing the average rainfall in the State, together with the normal rainfall for a long period of years, and the flow of some of the streams in the State, are given in a chapter entitled " Water Supply Statistics and Flow of Streams."

EXAMINATION OF WATER SUPPLIES.

Water Supply of the Metropolitan Water District.

During the year 1902 water has been supplied from the Metropolitan Water Works to the following cities and towns: —

CITY OR TOWN.	Population in 1900.
Boston,	560,892
Somerville,	61,643
Chelsea,	34,072
Malden,	33,664
Arlington,	8,603
Quincy,	23,899
Everett,	24,336
Medford,*	18,244
Melrose,	12,962
Watertown,	9,706
Revere,	10,395
Winthrop,	6,058
Belmont,	3,929
Nahant,	1,152
Stoneham,	6,197
Swampscott,	4,548
Milton,*	6,578
Total population of cities and towns supplied,	826,878

* Partially supplied from local sources.

In addition to the cities and towns in the above table, a small portion of the town of Saugus has been supplied with water from the metropolitan works, and during the summer months a small quantity of water was supplied to the town of Lexington. The town of Milton was supplied in part from the metropolitan works after March 1, and since August 22 the entire supply of the town has been taken from this source.

The principal source of supply of the district during the year has been Framingham Reservoir No. 3, which is supplied chiefly from the Sudbury Reservoir, which in turn receives through the Wachusett aqueduct the water of the south branch of the Nashua River. Water was drawn from these sources and from Lake Cochituate each month during the year. Water was drawn from Framingham Reservoir No. 2 from June to November inclusive, and from Framingham Reservoir No. 1 during the months of May and June.

METROPOLITAN WATER DISTRICT.

Chemical Examination of Water from the Sources of Supply of the Metropolitan Water District.

Quinepoxet River, Holden.

[Parts per 100,000.]

	Color.	Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Total.	Loss on Ignition.	Free.	Albuminoid.				Nitrates.	Nitrites.		
					Total	Dissolved.	Suspended.					
Average of 6 samples collected in 1902,	.45	3.57	1.65	.0026	.0223	.0175	.0048	.30	.0050	.0001	.65	0.5
Average of ten previous years, . .	.62	3.81	1.64	.0023	.0243	.0201	.0042	.23	.0054	.0001	.66	0.7

Odor in 1902, generally faintly vegetable, becoming stronger on heating; occasionally unpleasant.

Stillwater River, Sterling.

Average of 6 samples collected in 1902,	.39	3.29	1.46	.0021	.0163	.0144	.0019	.16	.0020	.0000	.58	0.6
Average of ten previous years, . .	.46	3.29	1.34	.0012	.0170	.0150	.0020	.16	.0038	.0000	.54	0.7

Odor in 1902, generally faintly vegetable, becoming stronger on heating; occasionally unpleasant.

South Branch of Nashua River, above Clinton.

Average of 12 samples collected in 1902,	.38	3.62	1.49	.0025	.0190	.0161	.0029	.22	.0050	.0001	.50	0.9
Average of eight previous years, . .	.41	3.73	1.37	.0016	.0186	.0157	.0029	.22	.0056	.0000	.47	1.1

Odor in 1902, generally faintly vegetable, becoming stronger on heating; occasionally unpleasant.

Sudbury Reservoir, Surface.

Average of 51 samples collected in 1902,	.24	3.73	1.39	.0026	.0145	.0122	.0023	.24	.0084	.0001	.40	1.2
Average of four previous years, . .	.26	3.84	1.35	.0026	.0170	.0142	.0028	.23	.0091	.0001	.39	1.2

Odor in 1902, generally faintly vegetable, becoming stronger on heating.

Sudbury Reservoir, Mid-depth.

Average of 51 samples collected in 1902,	.24	3.75	1.39	.0033	.0141	.0121	.0020	.25	.0091	.0001	.40	1.2
Average of four previous years, . .	.28	4.07	1.44	.0039	.0156	.0137	.0019	.24	.0109	.0001	.40	1.3

Odor in 1902, generally faintly vegetable, becoming stronger on heating.

Sudbury Reservoir, Bottom.

Average of 51 samples collected in 1902,	.25	3.77	1.38	.0040	.0136	.0121	.0015	.25	.0097	.0001	.40	1.2
Average of four previous years, . .	.28	4.17	1.45	.0046	.0152	.0135	.0017	.25	.0129	.0001	.39	1.4

Odor in 1902, generally faintly vegetable, becoming stronger on heating.

METROPOLITAN WATER DISTRICT.

CHEMICAL EXAMINATION OF WATER FROM THE SOURCES OF SUPPLY OF THE METROPOLITAN WATER DISTRICT — *Continued.*

Framingham Reservoir, No. 3.

[Parts per 100,000.]

	Color.	Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Total.	Loss on Ignition.	Free.	Albuminoid.				Nitrates.	Nitrites.		
					Total.	Dissolved.	Sus-pended.					
Average of 12 samples collected in 1902,	.23	3.80	1.42	.0026	.0159	.0132	.0027	.28	.0076	.0001	.40	1.3
Average of four previous years, . .	.26	4.06	1.38	.0019	.0167	.0142	.0025	.25	.0097	.0001	.39	1.3

Odor in 1902, generally faintly vegetable, becoming stronger on heating. An unpleasant odor was observed in the samples collected in September and October.

Indian Brook, at Head of Hopkinton Reservoir.

Average of 6 samples collected in 1902,	1.54	5.72	3.14	.0051	.0329	.0306	.0023	.38	.0065	.0001	1.34	1.2
Average of eight previous years, . .	1.50	6.11	3.13	.0021	.0339	.0316	.0023	.47	.0037	.0000	1.52	1.5

Odor in 1902, faintly vegetable, becoming distinctly vegetable on heating.

Hopkinton Reservoir, Surface.

Average of 6 samples collected in 1902,	.53	3.55	1.82	.0034	.0204	.0173	.0031	.30	.0045	.0000	.66	0.8
Average of eight previous years, . .	.61	3.83	1.69	.0020	.0212	.0186	.0026	.34	.0041	.0001	.69	1.0

Odor in 1902, generally faintly vegetable, becoming stronger on heating.

Hopkinton Reservoir, Bottom.

Average of 6 samples collected in 1902,	.57	3.62	1.81	.0053	.0186	.0163	.0023	.29	.0042	.0000	.65	0.7
Average of eight previous years, . .	.63	3.89	1.68	.0037	.0187	.0165	.0022	.34	.0054	.0001	.67	1.0

Odor in 1902, generally faintly vegetable, becoming stronger on heating.

Cold Spring Brook, at Head of Ashland Reservoir.

Average of 6 samples collected in 1902,	1.30	4.60	2.70	.0033	.0315	.0283	.0032	.24	.0030	.0000	1.21	1.0
Average of eleven previous years, .	1.25	4.98	2.48	.0014	.0296	.0269	.0027	.28	.0046	.0000	1.17	1.2

Odor in 1902, vegetable.

Ashland Reservoir, Surface.

Average of 6 samples collected in 1902,	.48	2.94	1.52	.0016	.0187	.0167	.0020	.20	.0023	.0000	.61	0.5
Average of eleven previous years, .	.68	3.73	1.70	.0014	.0218	.0194	.0024	.26	.0040	.0001	.76	1.0

Odor in 1902, faintly vegetable, becoming distinctly vegetable on heating.

METROPOLITAN WATER DISTRICT.

CHEMICAL EXAMINATION OF WATER FROM THE SOURCES OF SUPPLY OF THE METROPOLITAN WATER DISTRICT — *Continued.*

Ashland Reservoir, Bottom.

[Parts per 100,000.]

	Color.	Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Total.	Loss on Ignition.	Free.	Albuminoid.				Nitrates.	Nitrites.		
					Total.	Dissolved.	Suspended.					
Average of 6 samples collected in 1902,	.62	3.41	1.69	.0024	.0201	.0188	.0013	.24	.0043	.0000	.69	0.9
Average of ten previous years, . .	.67	3.82	1.65	.0018	.0193	.0174	.0019	.26	.0067	.0000	.73	1.1

Odor in 1902, faintly vegetable, becoming distinctly vegetable on heating.

Sudbury River, at Head of Framingham Reservoir No. 2.

Average of 6 samples collected in 1902,	.89	4.22	2.27	.0027	.0236	.0211	.0025	.28	.0028	.0000	.93	0.9
Average of eleven previous years, .	.94	4.59	2.04	.0016	.0260	.0232	.0028	.31	.0075	.0001	.92	1.1

Odor in 1902, generally vegetable, becoming stronger on heating.

Framingham Reservoir No. 2.

Average of 6 samples collected in 1902,	.71	3.81	1.97	.0030	.0215	.0191	.0024	.27	.0047	.0000	.83	0.9
Average of eleven previous years, .	.84	4.30	1.91	.0014	.0232	.0205	.0027	.30	.0069	.0001	.85	1.1

Odor in 1902, generally faintly vegetable, becoming stronger on heating.

Lake Cochituate, Wayland.

Average of 12 samples collected in 1902,	.25	4.77	1.90	.0028	.0192	.0161	.0031	.42	.0100	.0002	.46	1.9
Average of eleven previous years, .	.23	4.83	1.62	.0019	.0194	.0161	.0033	.47	.0104	.0001	.42	2.0

Odor in 1902, generally faintly vegetable, becoming stronger on heating. The samples collected in January, February, March and April had unpleasant odors. A large number of microscopical organisms was found in many of the samples, including the organisms *Anabæna*, *Synura* and *Uroglena*.

Chestnut Hill Reservoir.

Average of 12 samples collected in 1902,	.27	3.79	1.42	.0027	.0156	.0137	.0019	.26	.0091	.0001	.41	1.3
Average of four previous years, . .	.29	3.96	1.45	.0022	.0160	.0140	.0020	.24	.0094	.0001	.40	1.3

Odor in 1902, vegetable, becoming stronger on heating.

Spot Pond, Stoneham.

Average of 12 samples collected in 1902,	.06	3.50	1.20	.0018	.0137	.0121	.0016	.26	.0025	.0000	.23	1.5

Odor, generally vegetable.

METROPOLITAN WATER DISTRICT.

Chemical Examination of Water from the Sources of Supply of the Metropolitan Water District — *Concluded.*

Faucet at State House, Boston.

[Parts per 100,000.]

	Color.	Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Total.	Loss on Ignition.	Free.	Albuminoid.				Nitrates.	Nitrites.		
					Total.	Dissolved.	Sus-pended.					
Average of 12 samples collected in 1902,	.26	3.93	1.56	.0016	.0139	.0119	.0020	.29	.0092	.0000	.40	1.3
Average of four previous years, . .	.28	4.03	1.43	.0010	.0151	.0135	.0016	.27	.0121	.0001	.40	1.4

Odor in 1902, generally faintly vegetable, becoming stronger on heating.

Faucets in Revere.

Average of 12 samples collected in 1902,	.12	3.86	1.37	.0015	.0140	.0122	.0018	.29	.0069	.0001	.32	1.6
Average of two previous years, . .	.14	4.24	1.31	.0012	.0152	.0136	.0016	.27	.0067	.0001	.32	1.7

Odor in 1902, generally vegetable.

Faucets in Quincy.

Average of 11 samples collected in 1902,	.24	3.80	1.39	.0011	.0135	.0119	.0016	.30	.0128	.0001	.39	1.5
Average for 1901, ...	.24	4.45	1.68	.0010	.0152	.0134	.0018	.31	.0183	.0001	.41	1.8

Odor in 1902, frequently faintly vegetable, becoming stronger on heating.

Water Supply of Abington and Rockland.

Big Sandy Pond in Pembroke.

Average of 4 samples collected in 1902,	.14	3.26	1.31	.0025	.0152	.0133	.0019	.60	.0027	.0000	.25	0.6
Average of seven previous years, . .	.10	3.17	1.13	.0011	.0166	.0146	.0020	.65	.0020	.0000	.23	0.5

Odor in 1902, faintly vegetable or unpleasant when heated.

Acton.

Nagog Pond.

Average of 4 samples collected in 1902,	.04	2.39	1.04	.0014	.0171	.0151	.0020	.29	.0052	.0001	.22	0.4
Average of two previous years, . .	.05	2.15	0.87	.0050	.0194	.0154	.0040	.24	.0016	.0000	.21	0.3

Odor in 1902, occasionally faintly vegetable.

ADAMS FIRE DISTRICT.

Water Supply of Adams Fire District.

Bassett Brook.

[Parts per 100,000.]

	Color.	Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Total.	Loss on Ignition.	Free.	Albuminoid.				Nitrates.	Nitrites.		
					Total.	Dissolved.	Sus-pended.					
Average of 4 samples collected in 1902,	.03	4.19	1.30	.0007	.0038	.0031	.0007	.06	.0192	.0000	.14	2.7
Average of six previous years, . .	.04	3.50	0.89	.0003	.0043	.0036	.0007	.08	.0162	.0000	.13	2.2

Dry Brook.

Average of 4 samples collected in 1902,	.19	6.67	2.31	.0015	.0115	.0092	.0023	.08	.0077	.0001	.35	4.5
Average of six previous years, . .	.24	6.75	1.80	.0009	.0101	.0089	.0012	.10	.0097	.0000	.36	4.5

Odor in 1902, generally faintly vegetable, becoming stronger on heating.

Waters Examined in Connection with Advice with Reference to a Proposed Water Supply for the Adams Fire District. (See also page 5.)

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1902.												
41373	July 24	None.	V. slight.	.00	12.30	.0006	.0016	.13	.0390	.0000	.00	7.4	.0050
42303	Sept. 17	None.	None.	.00	12.30	.0000	.0008	.13	.0300	.0000	.03	9.6	.0050
41858	Aug. 20	None.	V. slight.	.00	13.10	.0008	.0010	.11	.0520	.0000	.00	6.1	.0020
41859	Aug. 20	None.	None.	.00	13.60	.0000	.0006	.10	.0380	.0000	.00	6.4	.0020
42304	Sept. 17	None.	None.	.00	13.00	.0000	.0006	.11	.0360	.0000	.02	10.6	.0090
42305	Sept. 17	None.	None.	.00	15.30	.0000	.0016	.11	.0440	.0000	.03	10.6	.0050
42306	Sept. 17	None.	None.	.00	14.00	.0000	.0002	.10	.0500	.0000	.02	10.8	.0050

The first two samples were collected from test well No. 1; the third, from test well No. 2; the fourth and fifth, from test well No. 3; the sixth, from test well No. 4; the last, from test well No. 5,— all of the wells being located on the westerly bank of the Hoosick River in the valley of a small tributary a short distance above Cheshire Harbor.

WATER SUPPLY OF AMESBURY. — POWOW HILL WATER COMPANY.

Wells near Main Street.

[Parts per 100,000.]

		Residue on Evaporation.		Ammonia.					Nitrogen as				
					Albuminoid.								
	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Hardness.	Iron.
Average of 6 samples collected in 1902.	.10	10.12	–	.0015	.0011	–	–	.81	.1075	.0002	.04	4.3	.0377
Average for 1901, ...	.10	10.73	–	.0009	.0013	–	–	.60	.0390	.0001	.04	4.7	.0408

Wells near Market Street.

Average of 6 samples collected in 1902.	.01	24.70	–	.0030	.0019	–	–	1.32	.0053	.0003	.03	10.5	.0052
Average for 1901, ...	.03	24.20	–	.0039	.0043	–	–	1.28	.0028	.0001	.07	8.8	.0134

WATER SUPPLY OF AMHERST. — AMHERST WATER COMPANY.

Amethyst Brook Reservoir.

Average of 4 samples collected in 1902.	.53	3.37	1.70	.0025	.0194	.0177	.0017	.14	.0027	.0001	.69	0.4	–
Average of two previous years, .	.42	3.55	1.42	.0028	.0166	.0150	.0016	.14	.0039	.0000	.63	0.4	–

Odor in 1902, faintly vegetable, becoming distinctly vegetable on heating.

WATER SUPPLY OF ANDOVER.

Haggett's Pond.

Average of 4 samples collected in 1902.	.15	3.14	1.40	.0014	.0151	.0137	.0014	.29	.0020	.0000	.34	1.0	–
Average of eleven previous years,	.13	3.57	1.30	.0009	.0156	.0135	.0021	.33	.0027	.0000	.31	1.3	–

Odor in 1902, faintly vegetable, becoming stronger on heating.

WATER SUPPLY OF ARLINGTON.

(See *Metropolitan Water District*, pages 95-99.)

Ashfield.

Waters examined in Connection with Advice with Reference to a Proposed Water Supply for Ashfield. (See also page 6.)

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Sus-pended.		Nitrates.	Nitrites.		
	1902.														
39097	Feb. 21	V. slight.	V. slight.	.08	3.80	1.00	.0006	.0074	.0042	.0032	.10	.0190	.0000	.12	2.1
39098	Feb. 21	None.	Slight.	.10	4.30	1.15	.0004	.0032	.0024	.0008	.11	.0060	.0000	.20	2.5
39099	Feb. 21	None.	V. slight.	.01	2.95	0.50	.0002	.0018	-	-	.12	.0170	.0000	.10	1.7

The first sample was collected from Taylor Brook at Cape Road; the second, from Bear Swamp Brook at a road crossing in "Little Switzerland;" the last, from Creamery Brook, about one-quarter of a mile above the creamery.

WATER SUPPLY OF ATHOL. — ATHOL WATER COMPANY.

Large Reservoir in Phillipston.

[Parts per 100,000.]

	Color.	Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
					Albuminoid.								
		Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Sus-pended.		Nitrates.	Nitrites.			
Average of 3 samples collected in 1902.	.67	3.07	1.27	.0033	.0331	.0232	.0099	.12	.0040	.0000	.77	0.6	-
Average of eight previous years, .	.67	3.78	1.77	.0036	.0359	.0218	.0141	.14	.0058	.0000	.78	0.7	-

Odor in 1902, vegetable, becoming stronger or unpleasant on heating. A large number of microscopical organisms was found in two of the samples examined, consisting chiefly of the organism *Anabæna.*

Buckman Brook Reservoir.

Average of 3 samples collected in 1902.	.53	3.43	1.42	.0031	.0213	.0169	.0044	.10	.0027	.0000	.76	0.7	-
Average of three previous years,	.46	3.35	1.54	.0014	.0196	.0171	.0025	.13	.0049	.0000	.69	0.6	-

Odor in 1902, generally faintly vegetable, becoming stronger on heating.

WATER SUPPLY OF ATTLEBOROUGH.

Well.

Average of 7 samples collected in 1902.	.01	3.97	-	.0003	.0024	-	-	.32	.0089	.0000	.04	1.8	.0047
Average of nine previous years, .	.01	4.00	-	.0002	.0022	-	-	.35	.0140	.0000	.04	1.8	.0040

WATER SUPPLY OF AVON.

Well.

[Parts per 100,000.]

	Color.	Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Total.	Loss on Ignition.	Free.	Albuminoid.				Nitrates.	Nitrites.			
					Total.	Dissolved.	Suspended.						
Average of 7 samples collected in 1902.	.00	3.60	-	.0006	.0013	-	-	.34	.0517	.0000	.01	1.0	.0049
Average of three previous years, .	.01	3.64	-	.0003	.0011	-	-	.37	.0252	.0000	.02	1.0	.0048

WATER SUPPLY OF AYER.

Well.

Average of 6 samples collected in 1902.	.00	5.55	-	.0005	.0018	-	-	.52	.0475	.0000	.02	2.1	.0073
Average of three previous years, .	.01	5.72	-	.0004	.0018	-	-	.48	.0428	.0000	.03	2.4	.0061

WATER SUPPLY OF BARRE. — BARRE WATER COMPANY.

Reservoir.

September, 1902, ...	.08	4.15	1.50	.0250	.0366	.0302	.0064	.10	.0000	.0000	.34	1.4	-
Average of four previous years, .	.13	3.32	1.09	.0030	.0203	.0160	.0043	.14	.0063	.0000	.25	1.1	-

BEDFORD.

Water examined in Connection with Advice to the School Committee of Bedford.
(See also page 7.)

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
42131	1902. Sept. 9.	None.	None.	.00	12.80	.0006	.0036	1.42	.5000	.0000	.01	4.2	.0080

The sample was collected from a well located on the premises of J. B. Prescott, on North Street.

WATER SUPPLY OF BELMONT.

(See *Metropolitan Water District*, pages 95-99.)

BEVERLY.

WATER SUPPLY OF BEVERLY.

(See *Salem.*)

WATER SUPPLY OF BILLERICA.

Tubular Wells.

[Parts per 100,000.]

	Color.	Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Total.	Loss on Ignition.	Free.	Albuminoid.				Nitrates.	Nitrites.			
					Total.	Dissolved.	Sus-pended.						
Average of 6 samples collected in 1902.	.09	7.22	-	.0009	.0031	-	-	.26	.0087	.0000	.08	2.3	.0287
Average of three previous years, .	.04	6.03	-	.0006	.0020	-	-	.26	.0093	.0000	.05	2.2	.0211

WATER SUPPLY OF BOSTON.

(See *Metropolitan Water District*, pages 95-99.)

WATER SUPPLY OF BRAINTREE.

Filter Gallery.

[Parts per 100,000.]

	Color.	Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
			Free.	Albu-minoid.		Nitrates.	Nitrites.			
Average of 8 samples collected in 1902.	.04	4.99	.0022	.0047	.79	.0337	.0000	.12	1.8	.0059
Average of ten previous years, .	.06	5.14	.0009	.0062	.83	.0365	.0001	.13	1.8	.0141

WATER SUPPLY OF BRIDGEWATER AND EAST BRIDGEWATER. — THE BRIDGEWATERS WATER COMPANY.

Faucets in Bridgewater.

Average of 7 samples collected in 1902.	.13	6.47	.0007	.0031	.46	.0174	.0001	.07	2.2	.0651
Average of three previous years, .	.15	7.74	.0010	.0017	.42	.0072	.0000	.05	2.5	.0813

WATER SUPPLY OF STATE FARM, BRIDGEWATER.

Taunton River.

[Parts per 100,000.]

Number.	Date of Collection.	APPEARANCE.			RESIDUE ON EVAPORATION.		AMMONIA.				Chlorine.	NITROGEN AS		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	ALBUMINOID.				Nitrates.	Nitrites.		
								Total.	Dissolved	Suspended.					
38536	1901. Dec. 31	Decided.	Cons.	1.12	4.55	2.50	.0028	.0258	.0226	.0032	.39	.0140	.0001	1.22	0.8
39237	1902. Mar. 5	Decided.	Cons	0.95	3.90	2.10	.0022	.0214	.0176	.0038	.31	.0070	.0001	0.87	0.5
40326	June 3	V. slight.	Cons.	1.40	5.10	2.50	.0048	.0304	.0260	.0044	.57	.0180	.0003	1.11	1.0
40957	July 3	V. slight.	Cons.	1.20	5.25	2.50	.0016	.0332	.0272	.0060	.63	.0110	.0001	1.18	1.1
43027	Nov. 4	V. slight.	Slight.	0.90	6.60	2.60	.0084	.0248	.0212	.0036	.86	.0110	.0003	1.10	1.3
43362	Dec. 1	Slight.	V. slight.	1.10	7.25	3.25	.0090	.0230	.0212	.0018	.83	.0180	.0003	1.20	1.4
Av...	....	....	....	1.11	5.44	2.57	.0048	.0264	.0226	.0038	.60	.0132	.0002	1.11	1.0

Odor, distinctly vegetable or unpleasant.

Taunton River after Filtration.

[Parts per 100,000.]

Number.	Date of Collection.	APPEARANCE.			Residue on Evaporation.	AMMONIA.		Chlorine.	NITROGEN AS		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
38537	1901. Dec. 31	Decided.	V. slight.	1.00	4.40	.0020	.0192	.39	.0140	.0001	1.02	1.1	.0110
39238	1902. Mar. 5	Slight.	V. slight.	0.63	4.00	.0014	.0120	.31	.0100	.0001	0.68	0.6	.0060
40327	June 3	V. slight.	None.	1.10	4.50	.0012	.0178	.58	.0190	.0000	0.88	1.3	.0300
40958	July 3	V. slight.	None.	1.00	5.20	.0016	.0198	.62	.0100	.0000	0.79	1.3	.0250
43028	Nov. 4	None.	V. slight.	0.78	6.50	.0024	.0184	.88	.0200	.0000	1.05	1.4	.0130
43361	Dec. 1	None.	None.	0.70	6.75	.0034	.0174	.90	.0400	.0000	0.88	2.0	-
Av...	....	....	....	0.87	5.22	.0020	.0174	.61	.0188	.0000	0.88	1.3	.0170

Odor, occasionally vegetable.

BROCKTON.

WATER SUPPLY OF BROCKTON.

Salisbury Brook Storage Reservoir.

[Parts per 100,000.]

	Color.	Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Total.	Loss on Ignition.	Free.	Albuminoid.				Nitrates.	Nitrites.			
					Total.	Dissolved.	Suspended.						
Average of 12 samples collected in 1902.	.49	3.25	1.58	.0017	.0213	.0180	.0033	.32	.0009	.0000	.63	0.6	-
Average of eleven previous years,	.67	3.63	1.65	.0010	.0235	.0195	.0040	.37	.0023	.0000	.70	0.7	-

Odor in 1902, vegetable, becoming stronger on heating. A large number of microscopical organisms was found in many of the samples examined, consisting chiefly of the organism *Synedra*.

Silver Lake, in Pembroke.

	Color.	Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Total.	Loss on Ignition.	Free.	Albuminoid.				Nitrates.	Nitrites.			
					Total.	Dissolved.	Suspended.						
Average of 4 samples collected in 1902.	.09	2.86	1.11	.0006	.0135	.0122	.0013	.60	.0007	.0000	.24	0.5	-
Average of four previous years, .	.11	2.98	1.13	.0006	.0132	.0116	.0016	.63	.0017	.0000	.28	0.4	-

Odor in 1902, occasionally faintly vegetable. The organism *Melosira* was found in large numbers in the sample collected in February. Works are now being constructed to convey the water of Silver Lake to Brockton.

WATER SUPPLY OF BROOKLINE.

Faucet at Low-service Pumping Station.

	Color.	Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Total.	Loss on Ignition.	Free.	Albuminoid.				Nitrates.	Nitrites.			
					Total.	Dissolved.	Suspended.						
Average of 9 samples collected in 1902.	.03	9.32	-	.0036	.0040	-	-	.58	.0361	.0002	.06	4.7	.0084
Average of eight previous years, .	.03	8.89	-	.0016	.0034	-	-	.58	.0341	.0001	.09	4.4	.0035

For the results of examinations of water from the Charles River opposite the wells of the Brookline water works, see "Charles River" in the chapter on the "Examination of Rivers."

Water examined in Connection with Advice to the Holzer-Cabot Electric Company.
(See also page 7.)

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1902.												
42867	Oct. 24	None.	None.	.02	20.50	.0002	.0008	2.84	.4000	.0008	.04	9.6	.0040
42967	Oct. 30	V. slight.	V. slight.	.04	21.50	.0032	.0026	2.82	.3500	.0020	.01	10.2	.0250

The samples were collected from faucets supplied from two tubular wells on the premises of the company.

Water Supply of Cambridge.

Fresh Pond.

[Parts per 100,000.]

	Color.	Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness	Iron.
		Total.	Loss on Ignition.	Free.	Albuminoid.				Nitrates.	Nitrites.			
					Total.	Dissolved.	Sus-pended.						
Average of 12 samples collected in 1902.	.18	6.57	2.29	.0045	.0216	.0174	.0042	.55	.0307	.0003	.38	3.1	-
Average of eleven previous years,	.25	7.14	1.96	.0064	.0230	.0179	.0051	.63	.0274	.0005	.41	3.3	-

Odor in 1902, vegetable or unpleasant.

Stony Brook Storage Reservoir, Waltham.

Average of 12 samples collected in 1902.	.37	5.11	2.08	.0028	.0245	.0202	.0043	.40	.0107	.0002	.56	2.0	-
Average of eleven previous years,	.60	5.57	2.05	.0020	.0241	.0209	.0032	.43	.0189	.0001	.62	2.1	-

Odor in 1902, vegetable or unpleasant.

Upper Basin on Hobbs Brook.

Average of 12 samples collected in 1902.	.49	4.95	2.12	.0042	.0305	.0245	.0060	.33	.0074	.0001	.69	1.9	-
Average of three previous years, .	.48	5.57	2.32	.0033	.0360	.0294	.0066	.34	.0073	.0001	.75	2.0	-

Odor in 1902, vegetable, becoming stronger and occasionally unpleasant on heating.

Lower Basin on Hobbs Brook, Surface.

Average of 12 samples collected in 1902.	.16	4.97	1.96	.0034	.0281	.0228	.0053	.35	.0040	.0000	.45	2.1	-
Average of three previous years, .	.13	4.82	1.63	.0025	.0275	.0234	.0041	.35	.0042	.0001	.42	1.9	-

Odor in 1902, generally vegetable or unpleasant.

Lower Basin on Hobbs Brook, Bottom.

Average of 12 samples collected in 1902.	.16	4.90	1.88	.0024	.0239	.0194	.0045	.33	.0042	.0000	.44	2.1	-
Average of three previous years, .	.13	4.93	1.72	.0018	.0245	.0204	.0041	.35	.0047	.0001	.40	2.0	-

Odor in 1902, vegetable or unpleasant.

Water Supply of Canton.

Springdale Well.

Average of 7 samples collected in 1902.	.00	3.54	-	.0001	.0008	-	-	.31	.0037	.0000	.03	1.0	.0103
Average of three previous years,	.00	3.74	-	.0002	.0009	-	-	.33	.0049	.0000	.02	0.9	.0085

CANTON.

Well near Henry's Spring.

[Parts per 100,000.]

	Color.	Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
					Albuminoid.								
		Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.			
Average of 7 samples collected in 1902.	.03	3.86	-	.0001	.0021	-	-	.37	.0231	.0000	.05	1.1	.0071
Average of three previous years,	.11	4.64	-	.0004	.0040	-	-	.38	.0140	.0000	.14	1.4	.0080

Water Supply of Chelsea.

(See *Metropolitan Water District*, pages 95-99.)

Water Supply of Cheshire. — Cheshire Water Company.

Old Reservoir.

Average of 4 samples collected in 1902.	.01	3.82	0.92	.0005	.0024	.0023	.0001	.06	.0090	.0000	.08	2.9	-
Average of three previous years,	.04	4.23	-	.0006	.0032	-	-	.07	.0111	.0000	.07	2.9	-

New Reservoir.

Average of 4 samples collected in 1902.	.00	4.79	0.96	.0025	.0032	.0022	.0010	.06	.0065	.0000	.06	3.4	-

Water Supply of Chester.

Austin Brook Reservoir.

August, 1902, ...	.08	2.90	0.90	.0010	.0050	.0050	.0000	.06	.0040	.0001	.26	1.7	-

Water Supply of Chicopee.

Morton Brook Reservoir.

Average of 3 samples collected in 1902.	.04	3.55	0.88	.0006	.0041	.0037	.0004	.13	.0040	.0000	.08	0.7	-
Average of eight previous years,	.05	3.61	0.76	.0008	.0049	.0039	.0010	.13	.0071	.0000	.08	0.8	-

Cooley Brook Reservoir.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1902.														
38785	Jan. 28	V. slight.	Slight.	0.75	3.95	1.70	.0016	.0176	.0154	.0022	.13	.0060	.0000	0.70	0.8
39851	Apr. 29	V. slight.	Slight.	0.51	3.50	1.40	.0010	.0110	.0106	.0004	.09	.0040	.0000	0.50	0.8
41376	July 29	V. slight.	V. slight.	0.35	4.15	1.30	.0036	.0098	.0082	.0016	.10	.0040	.0001	0.40	0.8
42962	Oct. 29	V. slight.	Slight.	3.20	8.25	5.85	.0056	.0336	.0308	.0028	.17	.0010	.0000	2.98	1.1
Av...	....	....	....	1.20	4.96	2.56	.0029	.0180	.0162	.0018	.12	.0037	.0000	1.14	0.9
Average of eight previous years, .				0.68	4.19	1.42	.0015	.0148	.0114	.0034	.11	.0041	.0000	0.60	1.0

Odor in 1902, vegetable.

WATER SUPPLY OF COHASSET. — COHASSET WATER COMPANY.

Tubular Wells West of the Main Village (Old System).

[Parts per 100,000.]

	Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
Average of 3 samples collected in 1902.	.05	11.80	-	.0006	.0019	-	-	1.58	.0317	.0000	.02	5.2	.0183
Average of nine previous years, .	.12	15.40	-	.0003	.0018	-	-	1.82	.0240	.0000	.04	7.1	.0407

Tubular Wells in Ellms Meadow.

	Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
Average of 5 samples collected in 1902.	.00	11.67	-	.0002	.0011	-	-	1.43	.0749	.0000	.01	4.5	.0046
Average of four previous years, .	.00	12.29	-	.0000	.0011	-	-	1.35	.0582	.0000	.01	4.8	.0040

WATER SUPPLY OF CONCORD AND LINCOLN.

Sandy Pond.

	Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
Average of 4 samples collected in 1902.	.05	2.46	1.07	.0007	.0120	.0108	.0012	.24	.0015	.0000	.20	0.4	-
Average of five previous years, .	.05	2.52	0.89	.0008	.0133	.0118	.0015	.27	.0024	.0000	.18	0.7	-

Odor in February, 1902, faintly vegetable, becoming stronger on heating.

CONCORD.

WATER SUPPLY OF MASSACHUSETTS REFORMATORY, CONCORD. (See also page 8.)

(For analyses of samples collected from Nagog Pond, see Acton, page 99.)

WATER SUPPLY OF MIDDLESEX SCHOOL, CONCORD. (See also page 9.)

Bateman's Pond.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid.				Nitrates.	Nitrites.		
								Total.	Dissolved.	Suspended.					
40573	1902. June 18	Decided.	Cons.	.72	4.35	2.50	.0014	.0358	.0316	.0042	.20	.0000	.0000	1.03	1.1
41008	July 9	Decided.	Cons.	.75	4.65	2.55	.0022	.0416	.0330	.0086	.22	.0000	.0000	1.01	1.1
41663	Aug. 14	Slight.	Cons.	.66	4.80	2.40	.0008	.0388	.0304	.0084	.20	.0050	.0000	1.14	0.8
41837	Aug. 23	Decided.	Cons.	.70	4.60	2.50	.0068	.0424	.0350	.0074	.22	.0010	.0000	1.00	1.0
42087	Sept. 4	Decided.	Cons.	.56	4.50	2.25	.0024	.0396	.0336	.0060	.22	.0010	.0000	0.76	1.3
43053	Nov. 5	V. slight.	Cons.	.60	4.50	1.75	.0068	.0232	.0194	.0038	.26	.0010	.0000	0.86	1.0
Av...	....	....	....	.66	4.57	2.33	.0034	.0369	.0305	.0064	.22	.0013	.0000	0.97	1.0

Odor, unpleasant or disagreeable. The average number of organisms per cubic centimeter contained in these samples was 692.

Bateman's Pond, after Filtration.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
40574	1902. June 18	Slight.	Cons.	.07	4.00	.0006	.0176	.29	.0060	.0001	.16	1.0	.0800
41009	July 19	None.	V. slight.	.00	4.30	.0006	.0048	.35	.0140	.0000	.01	1.1	.0050
41664	Aug. 14	V. slight.	Cons.	.01	4.00	.0022	.0128	.25	.0100	.0003	.25	1.3	.0050
41838	Aug. 23	V. slight.	Cons.	.07	3.00	.0014	.0186	.24	.0020	.0000	.31	0.6	.0070
42088	Sept. 4	V. slight.	V. slight.	.02	3.00	.0044	.0150	.23	.0050	.0000	.30	1.0	.0050
43054	Nov. 5	V. slight.	V. slight.	.06	3.80	.0006	.0086	.28	.0090	.0000	.28	1.3	.0060
Av...	....	....	....	.04	3.68	.0016	.0129	.27	.0077	.0001	.22	1.0	.0180

Odor, occasionally faintly vegetable or unpleasant. The average number of organisms per cubic centimeter contained in these samples was 113.

Conway.

Water examined in Connection with Investigations relative to a proposed Water Supply for South Deerfield. (See also page 10.)

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		
40313	1902. June 3	None.	V. slight.	.04	4.25	0.35	.0008	.0050	.0048	.0002	.07	.0060	.0000	.08	3.1
40314	June 3	None.	V. slight.	.04	9.00	1.30	.0012	.0072	.0060	.0012	.12	.1200	.0003	.08	6.3

The first sample was collected from a small brook about three-quarters of a mile east of the village of Conway at the upper road crossing; the last, from a tributary of Mill River entering that stream from the south about a quarter of a mile above the line between Conway and Deerfield.

Water Supply of Cottage City. — Cottage City Water Company.

Springs.

[Parts per 100,000.]

	Color.	Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
					Albuminoid.								
		Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.			
Average of 4 samples collected in 1902.	.02	3.67	-	.0004	.0010	-	-	.93	.0107	.0000	.02	0.5	.0100
Average of 6 samples collected in 1901.	.02	4.00	-	.0002	.0010	-	-	.99	.0122	.0000	.02	0.7	.0122

Water Supply of Dalton Fire District.

Lower Reservoir.

Average of 4 samples collected in 1902.	.32	2.85	1.32	.0016	.0125	.0103	.0022	.07	.0150	.0001	.53	0.7	-

Odor, occasionally vegetable.

Water Supply of Danvers and Middleton.

Middleton Pond.

Average of 4 samples collected in 1902.	.50	4.00	1.85	.0024	.0192	.0170	.0022	.30	.0010	.0000	.67	1.0	-
Average of six previous years, .	.60	3.84	1.71	.0012	.0202	.0180	.0022	.34	.0024	.0000	.74	1.1	-

Odor in 1902, distinctly vegetable. The organism *Anabæna* was present in the samples examined in June and September.

DEDHAM.

WATER SUPPLY OF DEDHAM. — DEDHAM WATER COMPANY.

Large Well.

[Parts per 100,000.]

		Residue on Evaporation.		Ammonia.					Nitrogen as				
					Albuminoid.								
	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Hardness.	Iron.
Average of 7 samples collected in 1902.	.00	9.54	–	.0009	.0027	–	–	0.78	.1839	.0000	.02	3.8	.0060
Average of ten previous years, .	.01	9.76	–	.0005	.0029	–	–	0.85	.1996	.0000	.04	4.0	.0021

Tubular Well.

		Residue on Evaporation.		Ammonia.					Nitrogen as				
					Albuminoid.								
	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Hardness.	Iron.
Average of 6 samples collected in 1902.	.01	14.54	–	.0016	.0013	–	–	1.40	.4320	.0001	.02	5.5	.0091
Average of two previous years, .	.00	12.07	–	.0004	.0013	–	–	1.10	.3543	.0002	.01	4.4	.0061

DEERFIELD. — SOUTH DEERFIELD WATER SUPPLY DISTRICT.

Waters examined in Connection with Advice relative to a proposed Water Supply.

(See also page 10.)

[Parts per 100,000.]

		Appearance.			Residue on Evaporation.		Ammonia.					Nitrogen as			
								Albuminoid.							
Number.	Date of Collection.	Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Hardness.
	1902.														
40315	June 3	None.	V. slight.	.00	5.50	0.35	.0002	.0028	.0018	.0010	.06	.0100	.0000	.03	3.8
40316	June 3	None.	Slight.	.05	6.40	1.35	.0004	.0040	.0036	.0004	.10	.0400	.0001	.07	5.0

The first sample was collected from Clapp's trout brook near the point where it enters Mill River; the last, from Mill River about half a mile above Clapp's trout brook. For analyses of other sources examined in this connection, see Whately and Conway.

WATER SUPPLY OF DRACUT. — AMERICAN WOOLEN COMPANY.

Well.

[Parts per 100,000.]

		Residue on Evaporation.		Ammonia.					Nitrogen as				
					Albuminoid.								
	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Hardness.	Iron.
Average of 6 samples collected in 1902.	.00	4.20	–	.0003	.0014	–	–	.21	.0202	.0000	.02	1.5	.0055
Average of 6 samples collected in 1901.	.00	4.17	–	.0007	.0018	–	–	.22	.0153	.0000	.02	1.4	.0057

WATER SUPPLY OF EAST BRIDGEWATER.

(See *Bridgewater.*)

WATER SUPPLY OF EASTHAMPTON.

Bassett Brook.

[Parts per 100,000.]

	Color.	Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Total.	Loss on Ignition.	Free.	Albuminoid.				Nitrates.	Nitrites.			
					Total.	Dissolved.	Sus-pended.						
Average of 6 samples collected in 1902.	.21	3.54	1.31	.0023	.0121	.0081	.0040	.11	.0047	.0001	.39	1.0	-
Average of eight previous years, .	.24	3.82	1.11	.0004	.0087	.0072	.0015	.11	.0061	.0000	.29	1.5	-

Odor in 1902, generally vegetable or unpleasant.

WATER SUPPLY OF EASTON. — NORTH EASTON VILLAGE DISTRICT.

Well.

Average of 7 samples collected in 1902.	.00	4.40	-	.0004	.0012	-	-	.45	.0573	.0000	.01	1.5	.0054
Average of 6 samples collected in 1901.	.00	4.52	-	.0002	.0018	-	-	.50	.0615	.0000	.00	1.6	.0047

WATER SUPPLY OF EVERETT.

(See *Metropolitan Water District*, pages 95–99.)

Water examined in Connection with Advice to the City Authorities. (See also page 12.)

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albu-minoid.		Nitrates.	Nitrites.			
	1902.												
42547	Oct. 2	None.	None.	.00	19.00	.0004	.0014	1.61	1.0000	.0000	.05	6.6	.0050
42726	Oct. 15	None.	None.	.00	19.50	.0002	.0012	1.77	0.8250	.0000	.02	6.7	.0070

The last sample contained 73 bacteria per cubic centimeter and the Colon bacillus was present. — The samples were collected from a spring on the estate of Brice Evans, corner of Linden and Church streets.

FAIRHAVEN.

WATER SUPPLY OF FAIRHAVEN. — FAIRHAVEN WATER COMPANY.

Tubular Wells.

[Parts per 100,000.]

	Color.	Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Total.	Loss on Ignition.	Free.	Albuminoid.				Nitrates.	Nitrites.			
					Total.	Dissolved.	Sus-pended.						
Average of 5 samples collected in 1902.	.45	6.24	–	.0004	.0104	–	–	.92	.0248	.0000	.61	1.7	.0066
Average of eight previous years, .	.17	5.80	–	.0003	.0050	–	–	.90	.0460	.0001	.24	1.7	.0110

WATER SUPPLY OF FALL RIVER.

North Watuppa Lake.

Average of 12 samples collected in 1902.	.17	3.34	1.33	.0014	.0174	.0149	.0025	.50	.0019	.0000	.41	0.6	–
Average of seven previous years,	.19	3.31	1.22	.0011	.0176	.0154	.0022	.55	.0039	.0000	.38	0.6	–

Odor in 1902, generally vegetable or unpleasant. The organism *Dinobryon* was present in large numbers in the samples collected during the first three months of the year, and *Anabæna* in the samples collected in July and October.

South Watuppa Lake.

Average of 4 samples collected in 1902.	.19	4.60	1.35	.0012	.0197	.0176	.0021	.69	.0025	.0001	.39	1.4	–
Average of four previous years, .	.23	4.42	1.47	.0016	.0213	.0187	.0026	.67	.0026	.0000	.41	1.1	–

Odor in 1902, vegetable or unpleasant. The organism *Dinobryon* was present in large numbers in the sample collected in February.

WATER SUPPLY OF FALMOUTH.

Tubular Wells.

Average of 6 samples collected in 1902.	.03	2.78	–	.0013	.0089	–	–	.91	.0003	.0000	.04	0.2	.0060
Average of two previous years, .	.00	2.85	–	.0004	.0087	–	–	.92	.0014	.0000	.04	0.1	.0044

Long Pond.

Average of 6 samples collected in 1902.	.00	2.89	0.97	.0023	.0089	.0087	.0002	.92	.0002	.0000	.08	0.2	–
Average of 12 samples collected in 1901.	.00	2.88	1.13	.0014	.0111	.0099	.0012	.92	.0014	.0000	.08	0.2	–

Odor in 1902, occasionally faintly vegetable.

WATER SUPPLY OF FITCHBURG.

Scott Reservoir.

Average of 4 samples collected in 1902.	.19	2.41	1.07	.0052	.0180	.0132	.0048	.15	.0017	.0000	.36	0.3	–
Average of eleven previous years,	.14	2.45	1.03	.0014	.0202	.0148	.0054	.16	.0036	.0000	.30	0.3	–

Odor in 1902, vegetable and unpleasant. The organism *Synura* was present in the sample examined in April.

Meetinghouse Pond, in Westminster.

[Parts per 100,000.]

	Color.	Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Total.	Loss on Ignition.	Free.	Albuminoid.				Nitrates.	Nitrites.			
					Total.	Dissolved.	Suspended.						
Average of 4 samples collected in 1902.	.08	2.63	1.11	.0011	.0134	.0119	.0015	.14	.0007	.0000	.28	0.3	–
Average of nine previous years, .	.08	2.50	0.97	.0013	.0152	.0129	.0023	.17	.0027	.0000	.26	0.6	–

Odor in 1902, occasionally unpleasant. The organism *Dinobryon* was present in all of the samples examined, and the organism *Uroglena* in the sample examined in April.

WATER SUPPLY OF FOXBOROUGH WATER SUPPLY DISTRICT.

Tubular Wells.

	Color.	Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Total.	Loss on Ignition.	Free.	Albuminoid.				Nitrates.	Nitrites.			
					Total.	Dissolved.	Suspended.						
Average of 7 samples collected in 1902.	.00	3.61	–	.0002	.0008	–	–	.34	.0446	.0000	.01	0.8	.0040
Average of five previous years, .	.00	3.45	–	.0001	.0005	–	–	.35	.0429	.0000	.01	0.8	.0027

WATER SUPPLY OF FRAMINGHAM. — FRAMINGHAM WATER COMPANY.

Filter Gallery.

	Color.	Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Total.	Loss on Ignition.	Free.	Albuminoid.				Nitrates.	Nitrites.			
					Total.	Dissolved.	Suspended.						
Average of 5 samples collected in 1902.	.03	8.14	–	.0034	.0041	–	–	.82	.0456	.0002	.05	3.6	.0158
Average of ten previous years, .	.03	7.13	–	.0026	.0048	–	–	.83	.0376	.0002	.07	3.1	.0121

Water examined in Connection with Advice to the Dennison Manufacturing Company. (See also page 12.)

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1902.												
40546	June 16	None.	None.	.00	12.70	.0018	.0004	.39	.0020	.0001	.03	6.4	.0040
41337	July 24	None.	None.	.00	12.70	.0026	.0008	.43	.0030	.0001	.01	6.1	.0050

The first sample contained 462 bacteria per cubic centimeter. —— The samples were collected from a tubular well on the premises of the Dennison Manufacturing Company.

FRANKLIN.

WATER SUPPLY OF FRANKLIN. — FRANKLIN WATER COMPANY.

Wells.

[Parts per 100,000.]

	Color.	Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
			Free.	Albuminoid.		Nitrates.	Nitrites.			
Average of 8 samples collected in 1902.	.45	6.27	.0012	.0130	0.72	.0913	.0001	.48	1.9	.0188
Average of eight previous years,	.24	7.68	.0006	.0078	0.74	.1715	.0001	.29	2.9	.0128

Odor, frequently vegetable or unpleasant. All of the samples probably contained surface water drawn from Beaver Pond.

Water examined in Connection with Advice to Wm. J. Whiting. (See also page 13.)

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
39807	**1902.** Apr. 25	V. slight.	Cons.	.08	18.20	.9600	.0220	3.05	1.0400	.0014	.25	3.3	.0080

Odor, unpleasant.——The sample was collected from a well at No. 3 McCarthy Street Extension.

WATER SUPPLY OF GARDNER. — GARDNER WATER COMPANY.

Crystal Lake.

[Parts per 100,000.]

	Color.	Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
					Albuminoid.								
		Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.			
Average of 3 samples collected in 1902.	.05	4.13	1.58	.0023	.0155	.0131	.0024	.29	.0057	.0001	.25	1.3	-
Average of nine previous years, .	.06	3.11	1.03	.0015	.0160	.0137	.0023	.32	.0063	.0000	.19	1.0	-

Odor in 1902, occasionally faintly vegetable when heated.

WATER SUPPLY OF GLOUCESTER.

(For advice with reference to the new reservoir at Haskell's Pond, see page 13.)

Dike's Brook Storage Reservoir.

[Parts per 100,000.]

	Color.	Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
					Albuminoid.								
		Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Sus-pended.		Nitrates.	Nitrites.			
Average of 4 samples collected in 1902.	.41	4.04	1.73	.0040	.0187	.0162	.0025	.83	.0040	.0000	.45	0.3	-
Average of ten previous years, .	.41	4.00	1.49	.0027	.0193	.0161	.0032	.88	.0046	.0000	.43	0.4	-

Odor in 1902, generally vegetable or unpleasant.

Wallace Pond.

Average of 4 samples collected in 1902.	.31	4.10	1.60	.0030	.0215	.0163	.0052	1.00	.0012	.0000	.44	0 4	-
Average of nine previous years, .	.51	4.55	1.76	.0019	.0271	.0197	.0074	1.10	.0034	.0000	.54	0.5	-

Odor in 1902, unpleasant, becoming stronger on heating.

WATER SUPPLY OF GREAT BARRINGTON FIRE DISTRICT.

Green River.

Average of 3 samples collected in 1902.	.02	8.43	1.20	.0021	.0035	.0031	.0004	.08	.0267	.0000	.07	6.1	-
Average of two previous years, .	.00	7.97	1.24	.0005	.0032	.0025	.0007	.10	.0316	.0000	.06	6.0	-

WATER SUPPLY OF GREENFIELD FIRE DISTRICT.

Glen Reservoir in Leyden.

Average of 4 samples collected in 1902.	.04	4.87	1.12	.0004	.0036	.0035	.0001	.12	.0135	.0000	.08	3.1	-
Average of three previous years, .	.04	5.05	0.96	.0008	.0060	.0054	.0006	.12	.0101	.0000	.09	3.1	-

Water examined in Connection with Advice to the Wiley & Russell Manufacturing Company. (See also page 14.)

[Parts per 100,000.]

Number.	Date of Collection	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albu-minoid		Nitrates.	Nitrites.			
41140	**1902.** July 15	None.	V. slight.	.00	5.20	.0000	.0008	.22	.0450	.0001	.10	1.9	.0040

The sample was collected from a spring in the rear of the factory of the Wiley & Russell Manufacturing Company.

GROTON.

WATER SUPPLY OF GROTON. — GROTON WATER COMPANY.

Well.

[Parts per 100,000.]

	Color.	Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
					Albuminoid.								
		Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Sus-pended.		Nitrates.	Nitrites.			
Average of 6 samples collected in 1902.	.01	4.48	-	.0001	.0007	-	-	.15	.0075	.0000	.01	2.0	.0048
Average of four previous years, .	.01	4.29	-	.0002	.0011	-	-	.17	.0074	.0000	.02	2.0	.0062

HADLEY.

Waters examined in Connection with Advice to Petitioners for Incorporation as the Hadley Water Company. (See also page 14.)

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Sus-pended.		Nitrates.	Nitrites.		
	1902.														
39089	Feb. 20	V. slight.	V. slight.	.08	3.55	1.00	.0018	.0042	.0030	.0012	.16	.0020	.0000	.11	1.8
39090	Feb. 20	V. slight.	Cons.	.06	3.75	0.75	.0010	.0056	.0020	.0036	.16	.0170	.0000	.12	1.8

The first sample was collected from Hart's Brook at the outlet of Pratt's millpond in Hadley; the last, from a tributary of Hart's Brook from the south, which enters it about 800 feet above the point where it crosses the highway.

WATER SUPPLY OF HATFIELD.

Reservoir.

[Parts per 100,000.]

	Color.	Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
					Albuminoid.								
		Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Sus-pended.		Nitrates.	Nitrites.			
Average of 4 samples collected in 1902.	.15	3.85	1.22	.0014	.0094	.0081	.0013	.11	.0097	.0001	.28	1.6	-
Average of four previous years, .	.18	3.89	1.17	.0017	.0073	.0063	.0010	.12	.0053	.0000	.31	1.6	-

Odor in 1902, occasionally vegetable.

WATER SUPPLY OF HAVERHILL.

Crystal Lake.

[Parts per 100,000.]

	Color.	Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
					Albuminoid.								
		Total.	Loss on Ignition.	Free.	Total.	Dissolved	Sus-pended.		Nitrates.	Nitrites.			
Average of 4 samples collected in 1902.	.21	2.96	1.37	.0013	.0161	.0142	.0019	.24	.0017	.0000	.42	0.8	-
Average of nine previous years, .	.19	3.05	1.26	.0010	.0190	.0161	.0029	.27	.0022	.0000	.36	1.0	-

Odor in 1902, occasionally vegetable.

Kenoza Lake.

Average of 4 samples collected in 1902.	.08	3.64	1.36	.0014	.0143	.0127	.0016	.38	.0007	.0000	.26	1.7	-
Average of eight previous years, .	.09	3.69	1.11	.0010	.0167	.0150	.0017	.40	.0017	.0000	.25	1.7	-

In 1902 a vegetable odor was developed in most of the samples when heated.

Lake Saltonstall.

Average of 4 samples collected in 1902.	.04	6.46	1.75	.0016	.0157	.0132	.0025	.75	.0015	.0001	.19	3.2	-
Average of nine previous years, .	.08	5.66	1.44	.0022	.0171	.0151	.0020	.68	.0044	.0000	.23	2.5	-

Odor in 1902, frequently unpleasant when heated. The organism *Anabæna* was present in large numbers in the samples examined in July and October, and the organism *Uroglena* in the sample examined in October.

Lake Pentucket.

Average of 4 samples collected in 1902.	.04	3.56	1.25	.0011	.0130	.0113	.0017	.38	.0030	.0001	.21	1.5	-
Average of nine previous years, .	.07	3.81	1.22	.0007	.0189	.0170	.0019	.42	.0015	.0000	.24	1.6	-

Johnson's Pond in Boxford and Groveland.

Average of 4 samples collected in 1902.	.13	3.93	1.37	.0015	.0153	.0140	.0013	.36	.0020	.0001	.35	1.9	-
Average of six previous years, .	.14	4.12	1.36	.0009	.0187	.0167	.0020	.36	.0028	.0000	.32	1.9	-

Odor in 1902, occasionally faintly vegetable when heated.

Millvale Reservoir on East Meadow River.

Average of 4 samples collected in 1902.	.61	4.95	2.07	.0023	.0211	.0194	.0017	.35	.0030	.0000	.78	1.6	-
Average of six previous years, .	.60	4.74	1.97	.0011	.0221	.0197	.0024	.30	.0032	.0000	.70	1.7	-

Odor in 1902, vegetable.

HINGHAM.

WATER SUPPLY OF HINGHAM. — HINGHAM WATER COMPANY. (See also page 15.)

Accord Pond.

[Parts per 100,000.]

		Residue on Evaporation.		Ammonia.					Nitrogen as				
					Albuminoid.								
	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Sus-pended.	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Hardness.	Iron.
Average of 8 samples collected in 1902.	.21	2.83	1.23	.0009	.0123	.0110	.0013	.55	.0010	.0000	.36	0.4	-
Average of nine previous years, .	.22	3.06	1.19	.0006	.0141	.0122	.0019	.63	.0033	.0000	.36	0.3	-

Odor in 1902, frequently unpleasant, becoming stronger on heating. The organism *Synura* was present in the samples examined in February and April.

Fulling Mill Pond.

	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Sus-pended.	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Hardness.	Iron.
Average of 6 samples collected in 1902.	.15	4.93	1.36	.0013	.0067	.0055	.0012	.72	.0088	.0000	.19	1.4	-
Average of nine previous years, .	.19	4.82	1.25	.0022	.0106	.0069	.0037	.72	.0142	.0000	.21	1.3	-

Odor in 1902, occasionally vegetable.

WATER SUPPLY OF HOLBROOK.

(See *Randolph.*)

WATER SUPPLY OF HOLLISTON. — HOLLISTON WATER COMPANY.

Well and Pond.

	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Sus-pended.	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Hardness.	Iron.
Average of 4 samples collected in 1902.	.25	3.70	-	.0009	.0095	-	-	.26	.0040	.0000	.26	1.3	.0247
Average of nine previous years, .	.23	4.00	-	.0005	.0091	-	-	.29	.0078	.0000	.26	1.5	.0163

WATER SUPPLY OF HOLYOKE. (See also page 18.)

Whiting Street Storage Reservoir.

	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Sus-pended.	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Hardness.	Iron.
Average of 6 samples collected in 1902.	.09	3.89	1.65	.0025	.0252	.0163	.0089	.14	.0022	.0001	.25	2.2	-
Average of eleven previous years,	.21	5.04	1.57	.0042	.0274	.0197	.0077	.13	.0067	.0001	.30	2.7	-

Odor in 1902, frequently vegetable, becoming unpleasant on heating. A large number of organisms was found in each of the samples examined. *Anabæna* was present in the samples collected in May and October, and *Uroglena* in the sample collected in January.

Fomar Reservoir on Manhan River in Southampton.

	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Sus-pended.	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Hardness.	Iron.
Average of 6 samples collected in 1902.	.37	3.58	1.44	.0015	.0113	.0103	.0010	.11	.0035	.0000	.50	1.3	-
Average of four previous years, .	.31	3.66	1.34	.0010	.0126	.0103	.0023	.10	.0026	.0000	.43	1.3	-

Odor in 1902, occasionally vegetable.

Wright and Ashley Ponds.

[Parts per 100,000.]

		Residue on Evaporation.		Ammonia.					Nitrogen as				
					Albuminoid.								
	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Hardness.	Iron.
Average of 6 samples collected in 1902.	.11	4.08	1.52	.0014	.0148	.0117	.0031	.13	.0025	.0000	.27	2.1	-
Average of four previous years, .	.11	4.27	1.29	.0031	.0195	.0160	.0035	.12	.0039	.0001	.27	2.3	-

Odor in 1902, occasionally vegetable, becoming unpleasant on heating. The organism *Uroglena* was present in the samples examined in January and March.

Waters examined in Connection with Advice to the Skinner Manufacturing Company. (See also page 20.)

[Parts per 100,000.]

		Appearance.				Ammonia.			Nitrogen as				
Number.	Date of Collection.	Turbidity.	Sediment.	Color.	Residue on Evaporation.	Free.	Albuminoid.	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Hardness.	Iron.
	1902.												
39969	May 7	Decided.	Slight.	.33	18.60	.0008	.0038	.86	.0010	.0001	.05	8.7	.1250
40272	May 29	Decided.	Cons.	.02	18.90	.0004	.0026	.91	.0030	.0000	.22	9.6	.1700
40521	June 16	Decided.	Slight.	-	20.20	.0014	.0024	.92	.0000	.0000	.04	10.3	.0900
39968	May 7	V. slight.	None.	.00	15.60	.0006	.0002	.52	.0000	.0000	.02	7.7	.0150
40273	May 29	V. slight.	V. slight.	.00	14.50	.0004	.0016	.69	.0030	.0000	.08	8.1	.0180
40520	June 16	None.	V. slight.	.00	16.70	.0010	.0012	.57	.0020	.0000	.01	9.1	.0130

The first three samples were collected from a tubular well near the corner of Appleton and Bigelow streets; the last three, from a tubular well at the corner of Appleton and Bond streets.

WATER SUPPLY OF HOPEDALE.

(See *Milford.*)

WATER SUPPLY OF HOPKINTON.

Tubular Wells.

[Parts per 100,000.]

		Residue on Evaporation.		Ammonia.					Nitrogen as				
					Albuminoid.								
	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Hardness.	Iron.
Average of 4 samples collected in 1902.	.00	11.90	-	.0002	.0022	-	-	1.10	.4725	.0000	.01	4.6	.0080
Average of two previous years, .	.00	11.60	-	.0003	.0016	-	-	1.20	.3611	.0000	.01	4.7	.0123

HUDSON.

WATER SUPPLY OF HUDSON.

Gates Pond in Berlin.

[Parts per 100,000.]

		Residue on Evaporation.		Ammonia.					Nitrogen as				
					Albuminoid.								
	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Hardness.	Iron.
Average of 4 samples collected in 1902.	.11	2.82	0.91	.0021	.0160	.0124	.0036	.19	.0077	.0001	.23	0.7	-
Average of ten previous years, .	.05	2.40	0.95	.0027	.0158	.0135	.0023	.22	.0031	.0000	.18	0.7	-

Odor in 1902, occasionally faintly vegetable.

Fosgate Brook in Berlin.

Average of 11 samples collected in 1902.	.86	4.61	1.98	.0031	.0201	.0175	.0026	.16	.0091	.0000	.88	1.1	-
Average of three previous years, .	.43	4.00	1.49	.0020	.0153	.0137	.0016	.19	.0179	.0000	.57	1.1	-

Odor in 1902, generally vegetable, becoming stronger on heating.

WATER SUPPLY OF HULL.

(See *Hingham.*)

WATER SUPPLY OF HUNTINGTON FIRE DISTRICT.

Cold Brook Reservoir.

June, 1902, ...	.17	3.00	1.10	.0030	.0190	.0158	.0032	.09	.0040	.0000	.41	1.1	-
Average of three previous years, .	.17	3.24	1.08	.0010	.0092	.0082	.0010	.11	.0034	.0000	.30	0.9	-

Odor in 1902, faintly vegetable, becoming stronger on heating.

WATER SUPPLY OF HYDE PARK AND MILTON. — HYDE PARK WATER COMPANY. (See also pages 20, 21.)

Tubular Wells near the Neponset River.

Average of 14 samples collected in 1902.	.04	9.55	-	.0066	.0034	-	-	1.04	.1037	.0002	.08	3.9	.0158
Average of nine previous years, .	.04	10.00	-	.0096	.0042	-	-	1.29	.1013	.0002	.10	4.2	.0171

For the results of examinations of water from the Neponset River opposite the wells of the Hyde Park Water Company, see "Neponset River" in the chapter on the "Examination of Rivers."

HYDE PARK AND MILTON.

Tubular Wells near Mother Brook.

[Parts per 100,000.]

	Color.	Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
			Free.	Albuminoid.		Nitrates.	Nitrites.			
Average of 14 samples collected in 1902.	.05	8.04	.0007	.0046	.85	.2026	.0000	.09	3.0	.0068
Average of 12 samples collected in 1901.	.01	9.03	.0010	.0042	.92	.2562	.0002	.08	3.5	.0067

Waters examined in Connection with Advice to the Town Authorities. (See also page 21.)

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1902.												
39147	Feb. 25	None.	V. slight.	.00	27.60	.0006	.0020	3.25	1.7200	.0000	.05	8.4	.0050
39146	Feb. 25	None.	None.	.00	26.80	.0002	.0024	2.94	1.3300	.0000	.06	7.1	.0050
39145	Feb. 25	V. slight.	Cons.	.01	27.80	.0044	.0050	2.33	2.0000	.0013	.08	7.9	.0600
39144	Feb. 25	None.	V. slight.	.01	16.00	.0100	.0108	1.46	0.1700	.0005	.12	6.7	.0070

The first sample was collected from a well at No. 22 Easton Avenue; the second, from a well at No. 23 Easton Avenue; the third, from a well at No. 14 Easton Avenue; the last, from a well at the corner of Easton Avenue and Bridge Street.

WATER SUPPLY OF IPSWICH.

Dow's Brook at Entrance to Storage Reservoir.

[Parts per 100,000.]

	Color.	Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
					Albuminoid.								
		Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.			
Average of 11 samples collected in 1902.	0.46	4.65	1.88	.0017	.0163	.0141	.0022	.50	.0038	.0000	0.57	1.5	-
Average of six previous years, .	0.43	4.67	1.63	.0010	.0138	.0115	.0023	.53	.0045	.0000	0.48	1.6	-

Odor in 1902, generally faintly vegetable, becoming stronger on heating.

IPSWICH.

Dow's Brook Storage Reservoir.

[Parts per 100,000.]

		Residue on Evaporation.		Ammonia.					Nitrogen as			
					Albuminoid.							
	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Hardness.
Average of 12 samples collected in 1902,	0.25	4.35	1.83	.0018	.0176	.0155	.0021	.56	.0038	.0000	0.41	1.5
Average of seven previous years, .	0.33	4.69	1.63	.0020	.0199	.0172	.0027	.59	.0057	.0001	0.44	1.6

Odor in 1902, generally faintly vegetable or unpleasant, becoming stronger on heating. A large number of organisms was found in many of the samples examined.

Bull Brook.

Average of 11 samples collected in 1902,	1.12	6.65	3.05	.0031	.0263	.0229	.0034	.61	.0062	.0001	1.09	2.1
Average of three previous years, . .	1.34	7.03	3.06	.0020	.0267	.0247	.0020	.69	.0074	.0001	1.26	2.3

Odor in 1902, faintly vegetable, becoming stronger on heating.

WATER SUPPLY OF KINGSTON.

Tubular Wells.

[Parts per 100,000.]

		Residue on Evaporation.		Ammonia.					Nitrogen as				
					Albuminoid.								
	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.	Chlorine.	Nitrstes.	Nitrites.	Oxygen Consumed.	Hardness.	Iron.
Average of 6 samples collected in 1902.	.00	4.50	-	.0002	.0011	-	-	.74	.0090	.0000	.01	0.9	.0042
Average of 6 samples collected in 1901.	.00	4.55	-	.0003	.0010	-	-	.74	.0065	.0000	.02	0.9	.0050

WATER SUPPLY OF LAWRENCE. (See also pages 21, 23.)

Merrimack River above Lawrence.

Average of 12 samples collected in 1902.	.37	4.06	1.71	.0077	.0218	.0159	.0059	.22	.0052	.0002	.59	0.9	-
Average of eleven previous years,	.40	3.98	1.51	.0064	.0209	.0166	.0043	.22	.0076	.0002	.53	1.2	-

Odor in 1902, faintly vegetable or unpleasant, becoming stronger on heating.

Merrimack River after Filtration.

[Parts per 100,000.]

	Color.	Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
					Albuminoid.								
		Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Sus-pended.		Nitrates.	Nitrites.			
Average of 12 samples collected in 1902.	.36	4.09	1.50	.0102	.0084	.0078	.0006	.23	.0225	.0002	.43	1.4	-
Average of eight previous years,	.40	5.08	3.52	.0116	.0101	.0089	.0012	.27	.0279	.0002	.35	2.1	-

Odor in 1902, occasionally faintly vegetable when heated.

Distributing Reservoir.

Average of 12 samples collected in 1902.	.29	4.07	1.55	.0049	.0093	.0085	.0008	.23	.0220	.0001	.41	1.3	-
Average of eight previous years, .	.28	4.52	1.48	.0043	.0108	.0093	.0015	.26	.0234	.0001	.33	1.7	-

Odor in 1902, occasionally faintly vegetable or unpleasant.

WATER SUPPLY OF LEE. — BERKSHIRE WATER COMPANY.

Lower Reservoir.

Average of 4 samples collected in 1902.	.17	3.22	1.42	.0018	.0088	.0078	.0010	.07	.0047	.0000	.40	1.3	-
Average of four previous years, .	.29	3.39	1.46	.0008	.0133	.0120	.0013	.07	.0051	.0001	.48	1.5	-

Odor in 1902, frequently faintly vegetable.

WATER SUPPLY OF LEICESTER WATER SUPPLY DISTRICT.

Wells.

Average of 4 samples collected in 1902.	.06	6.57	-	.0031	.0032	-	-	.20	.1002	.0000	.08	2.3	.0362
Average of ten previous years, .	.13	5.38	-	.0006	.0034	-	-	.23	.0673	.0001	.14	2.1	.0119

WATER SUPPLY OF LENOX. — LENOX WATER COMPANY.

Storage Reservoir.

Average of 4 samples collected in 1902.	.07	7.73	1.89	.0016	.0120	.0096	.0024	.08	.0052	.0000	.19	5.5	-
Average of four previous years, .	.06	7.94	1.11	.0018	.0129	.0109	.0020	.09	.0039	.0000	.16	5.8	-

Odor in 1902, frequently unpleasant.

WATER SUPPLY OF LEOMINSTER. (See also page 24.)

Haynes Reservoir.

Average of 4 samples collected in 1902.	.19	2.57	1.34	.0075	.0305	.0222	.0083	.12	.0022	.0000	.39	0.2	-
Average of ten previous years, .	.25	2.52	1.37	.0055	.0364	.0222	.0142	.14	.0034	.0000	.42	0.3	-

Odor in 1902, vegetable or unpleasant, becoming stronger on heating. A large number of organisms was found in each of the samples examined. *Uroglena* was present in August and November.

LEOMINSTER.

Morse Reservoir.

[Parts per 100,000.]

	Color.	Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Total.	Loss on Ignition.	Free.	Albuminoid.				Nitrates.	Nitrites.			
					Total.	Dissolved.	Suspended.						
Average of 4 samples collected in 1902.	.23	2.26	1.16	.0034	.0198	.0156	.0042	.12	.0020	.0000	.37	0.2	-
Average of nine previous years, .	.28	2.37	1.16	.0030	.0206	.0160	.0046	.14	.0026	.0000	.41	0.3	-

Odor in 1902, vegetable, becoming stronger on heating. A large number of organisms was found in each of the samples examined. *Uroglena* was present in the samples collected in May and August.

Fall Brook, above Fall Brook Reservoir.

Average of 12 samples collected in 1902.	.20	2.37	1.09	.0013	.0157	.0125	.0032	.14	.0020	.0000	.38	0.3	-
Average of five previous years, .	.38	2.65	1.22	.0007	.0147	.0131	.0016	.14	.0030	.0000	.50	0.4	-

Odor in 1902, frequently faintly vegetable, becoming stronger, and occasionally unpleasant, on heating.

Fall Brook Reservoir, at Surface.

Average of 12 samples collected in 1902.	.14	2.27	1.06	.0011	.0149	.0122	.0027	.14	.0013	.0000	.33	0.2	-
Average of five previous years, .	.19	2.27	1.07	.0012	.0170	.0139	.0031	.15	.0027	.0000	.34	0.3	-

Odor in 1902, faintly vegetable, becoming stronger, and frequently unpleasant, on heating. The organism *Uroglena* was present in the samples examined in March, April, September, October and November.

WATER SUPPLY OF LEXINGTON.

Faucets in Town.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid.				Nitrates.	Nitrites.		
								Total.	Dissolved.	Suspended.					
	1902.														
38541	Jan. 6	Slight.	Slight.	0.72	9.40	4.25	.0022	.0204	.0192	.0012	.53	.2300	.0002	1.04	3.6
39302	Mar. 13	V. slight.	V. slight.	1.50	10.80	5.15	.0034	.0308	.0296	.0012	.62	.1080	.0002	1.54	4.3
40034	May 12	V. slight.	Slight.	0.39	8.85	3.25	.0010	.0104	.0096	.0008	.61	.2150	.0003	0.44	4.3
41330	July 24	None.	None.	0.00	8.30	-	.0010	.0028	-	-	.44	.0920	.0000	0.05	3.6
42257	Sept. 16	V. slight.	None.	0.11	4.00	-	.0012	.0138	-	-	.30	.0040	.0000	0.08	1.7
43064	Nov. 10	V. slight.	Slight.	0.17	11.50	-	.0016	.0094	.0078	.0016	.58	.1800	.0003	0.23	4.6

Odor, occasionally faintly vegetable.

LEXINGTON.

Water examined in Connection with Advice relative to Additional Water Supply.
(See also page 26.)

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1902.												
39409	Mar. 25	Slight.	Cons.	.01	7.50	.0004	.0006	.20	.0050	.0000	0.03	1.4	.0450
39445	Mar. 27	None.	None.	.00	4.40	.0000	.0006	.24	.0100	.0000	0.03	1.3	.0070
39446	Mar. 27	None.	None.	.00	4.30	.0000	.0008	.24	.0090	.0000	0.02	1.3	.0100
39473	Mar. 28	None.	None.	.00	4.60	.0000	.0006	.24	.0140	.0000	0.01	1.7	.0060
39492	Apr. 1	None.	V. slight.	.01	5.70	.0006	.0008	.28	.0220	.0000	0.01	1.8	.0040
39499	Apr. 1	None.	None.	.00	5.10	.0000	.0006	.26	.0200	.0000	0.02	1.7	.0040
39511	Apr. 2	None.	None.	.02	5.50	.0000	.0004	.26	.0280	.0000	0.02	1.6	.0060
39527	Apr. 3	None.	None.	.01	5.40	.0000	.0002	.28	.0270	.0000	0.02	1.7	.0050
39539	Apr. 4	None.	None.	.00	5.30	.0006	.0014	.28	.0270	.0000	0.02	1.7	.0040
39543	Apr. 5	None.	None.	.01	5.60	.0002	.0008	.27	.0240	.0000	0.01	1.7	.0050
39566	Apr. 7	None.	None.	.01	5.80	.0008	.0020	.28	.0220	.0000	0.02	1.8	.0050

The samples were collected, during a pumping test, from a group of tubular wells situated in the meadow south of the pumping station. The pumping test was started March 24, the rate of pumping being about 125,000 gallons per day.

WATER SUPPLY OF LINCOLN.

(See *Concord.*)

WATER SUPPLY OF LONGMEADOW.

Cooley Brook.

[Parts per 100,000.]

	Color.	Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
					Albuminoid.							
		Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		
Average of 4 samples collected in 1902,	.10	4.27	1.31	.0015	.0087	.0063	.0024	.16	.0277	.0002	.19	2.0
Average of four previous years, . .	.06	4.75	1.12	.0014	.0046	.0039	.0007	.17	.0319	.0001	.09	2.5

Odor in 1902, frequently faintly vegetable or unpleasant when heated.

WATER SUPPLY OF LOWELL.

Merrimack River above Lowell.

Average of 13 samples collected in 1902,	.34	3.54	1.51	.0045	.0155	.0132	.0023	.16	.0052	.0001	.59	0.8
Average of eleven previous years, .	.36	3.59	1.38	.0035	.0168	.0136	.0032	.17	.0072	.0001	.49	1.1

Odor in 1902, faintly vegetable or unpleasant, becoming stronger on heating.

LOWELL.

Tubular Wells in the Valley of the Merrimack River near the Pawtucket Boulevard.

[Parts per 100,000.]

	Color.	Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
			Free.	Albuminoid.		Nitrates.	Nitrites.			
Average of 13 samples collected in 1902.	.07	4.03	.0043	.0035	.21	.0166	.0000	.08	1.5	.0297
Average of six previous years, . .	.08	4.40	.0080	.0031	.27	.0242	.0001	.07	1.8	.0311

Pumping Station No. 1.

	Color.	Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
			Free.	Albuminoid.		Nitrates.	Nitrites.			
Average of 12 samples collected in 1902.	.04	4.30	.0026	.0035	.24	.0343	.0000	.09	1.6	.0207
Average of three previous years, .	.07	4.50	.0055	.0036	.28	.0274	.0001	.08	1.8	.0259

The samples represent water from the Boulevard wells.

WATER SUPPLY OF LUDLOW.

(See *Springfield.*)

WATER SUPPLY OF LYNN AND SAUGUS.

Breed's Pond.

[Parts per 100,000.]

	Color.	Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Total.	Loss on Ignition.	Free.	Albuminoid.				Nitrates.	Nitrites.		
					Total.	Dissolved.	Suspended.					
Average of 12 samples collected in 1902,	.38	3.45	1.62	.0033	.0214	.0180	.0034	.42	.0027	.0000	.55	0.8
Average of eleven previous years, .	.44	3.62	1.42	.0026	.0208	.0176	.0032	.51	.0037	.0001	.49	0.9

Odor in 1902, vegetable or unpleasant, becoming stronger on heating. A large number of organisms was found in most of the samples examined. *Anabœna* was present in June, July, August, October and November, and *Uroglena* in August.

Birch Pond.

	Color.	Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Total.	Loss on Ignition.	Free.	Albuminoid.				Nitrates.	Nitrites.		
					Total.	Dissolved.	Suspended.					
Average of 12 samples collected in 1902,	.34	3.50	1.49	.0048	.0246	.0198	.0048	.37	.0046	.0001	.47	0.7
Average of eleven previous years, .	.47	4.16	1.66	.0034	.0266	.0215	.0051	.54	.0057	.0001	.51	1.2

Odor in 1902, vegetable or unpleasant, becoming stronger on heating. A large number of organisms was found in each of the samples examined. *Anabœna* was present in October, and *Uroglena* in January, April, May and July.

LYNN AND SAUGUS.

Walden Pond.

[Parts per 100,000.]

	Color.	Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Total.	Loss on Ignition.	Free.	Albuminoid.				Nitrates.	Nitrites.		
					Total.	Dissolved	Sus-pended.					
Average of 7 samples collected in 1902,	.48	3.34	1.50	.0031	.0288	.0211	.0077	.32	.0017	.0000	.70	0.4
Average of eleven previous years, .	.75	3.87	1.92	.0053	.0394	.0283	.0111	.41	.0044	.0001	.69	0.6

Odor in 1902, distinctly vegetable or unpleasant. A large number of organisms was found in each of the samples examined. *Synura* was present in January, February, March and April, and *Uroglena* in March, April and May.

Glen Lewis Pond.

Average of 9 samples collected in 1902,	.25	2.98	1.38	.0058	.0260	.0188	.0072	.33	.0016	.0000	.43	0.4
Average of ten previous years, . .	.47	3.68	1.80	.0104	.0468	.0285	.0183	.40	.0054	.0001	.51	0.5

Odor in 1902, faintly vegetable or unpleasant, becoming stronger on heating. A large number of organisms was found in each of the samples examined. *Anabæna* was present in July, August and September, and *Uroglena* in April, May, July and August.

Hawkes Pond.

Average of 12 samples collected in 1902,	.26	3.48	1.54	.0033	.0202	.0175	.0027	.39	.0022	.0000	.50	0.8
Average of five previous years, . .	.43	4.56	1.89	.0031	.0262	.0219	.0043	.47	.0055	.0001	.60	1.6

Odor in 1902, generally faintly vegetable, becoming stronger on heating. The organism *Uroglena* was present in the sample examined in November.

Saugus River, at Montrose.

Average of 11 samples collected in 1902,	.95	7.50	3.48	.0042	.0329	.0292	.0037	.65	.0047	.0001	.93	3.0
Average of four previous years, . .	.76	7.48	3.05	.0047	.0335	.0295	.0040	.65	.0059	.0002	.93	3.1

Odor in 1902, generally faintly vegetable, becoming stronger on heating.

Faucet in Lynn.

Average of 11 samples collected in 1902,	.32	3.38	1.50	.0029	.0185	.0159	.0026	.37	.0060	.0001	.45	0.8
Average of eight previous years, .	.52	4.40	1.77	.0020	.0210	.0184	.0026	.52	.0065	.0001	.58	1.4

Odor in 1902, generally faintly vegetable, becoming stronger on heating.

LYNNFIELD.

Water examined in Connection with Advice to J. F. Smith. (See also page 27.)

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albu-minoid.		Nitrates.	Nitrites.			
41120	1902. July 15	None.	None.	.00	4.80	.0006	.0014	.32	.0120	.0000	.01	2.3	.0050

The sample was collected from Pocahontas Spring, off Lowell Street.

MALDEN.

WATER SUPPLY OF MALDEN.

(See *Metropolitan Water District*, pages 95–99.)

WATER SUPPLY OF MANCHESTER. (See also page 27.)

Large Well.

[Parts per 100,000.]

	Color.	Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
			Free.	Albuminoid.		Nitrates.	Nitrites.			
Average of 7 samples collected in 1902.	.00	11.55	.0001	.0008	1.85	.1618	.0000	.02	3.6	.0087
Average of ten previous years, . .	.00	10.30	.0001	.0007	1.83	.1139	.0000	.02	3.5	.0039

Tubular Wells, near Coolidge Spring.

	Color.	Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
			Free.	Albuminoid.		Nitrates.	Nitrites.			
Average of 4 samples collected in 1902.	.00	11.02	.0004	.0011	1.30	.2193	.0000	.02	2.6	.0070
Average of 2 samples collected in 1901.	.00	9.30	.0013	.0024	1.28	.1700	.0000	.00	2.3	.0045

Water examined in Connection with Advice relative to Additional Water Supply.

(See also page 28.)

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1902.												
43058	Nov. 9	V. slight.	None.	.18	12.00	.0040	.0006	1.48	.0000	.0000	.02	4.3	.0450
43059	Nov. 9	V. slight.	None.	.28	11.00	.0028	.0006	1.25	.0000	.0001	.02	4.0	.0700
43060	Nov. 9	Slight.	None.	.32	8.70	.0034	.0004	1.74	.0000	.0000	.03	3.8	.0700
43061	Nov. 9	Decided.	None.	.60	10.50	.0024	.0004	1.12	.0000	.0000	.08	3.9	.1200
43062	Nov. 9	V. slight.	None.	.11	15.00	.0072	.0012	1.84	.0000	.0000	.02	4.0	.0350
43063	Nov. 9	V. slight.	None.	.29	11.00	.0036	.0014	1.02	.0000	.0000	.02	4.2	.0650

The samples were collected from tubular wells located in the valley of Saw Mill Brook, about one and one-half miles north of the village of Manchester. The first four samples were collected from wells located on the easterly side of the road from Manchester to Essex; the last two, from wells on the westerly side of that road.

MANSFIELD WATER SUPPLY DISTRICT.

WATER SUPPLY OF MANSFIELD WATER SUPPLY DISTRICT.

Well.

[Parts per 100,000.]

	Color.	Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
			Free.	Albuminoid.		Nitrates.	Nitrites.			
Average of 6 samples collected in 1902.	.00	2.69	.0002	.0004	.23	.0015	.0000	.00	0.5	.0046
Average of three previous years, .	.00	2.80	.0001	.0008	.28	.0028	.0000	.01	0.6	.0020

WATER SUPPLY OF MARBLEHEAD.

Collecting Well No. 1.

Average of 5 samples collected in 1902.	.07	17.56	.0121	.0022	2.27	.0222	.0002	.09	7.2	.1760
Average of eleven previous years, .	.07	17.43	.0065	.0022	2.95	.0610	.0002	.04	7.5	.1003

The samples represent a mixture of water from collecting well No. 1 with water from collecting well No. 2, which flows into it.

Collecting Well No. 2.

Average of 4 samples collected in 1902.	.01	17.47	.0255	.0034	1.55	.0030	.0001	.13	6.9	.4900
Average of four previous years, .	.10	15.95	.0239	.0035	1.66	.0053	.0000	.07	6.1	.3128

WATER SUPPLY OF MARLBOROUGH.

Lake Williams.

[Parts per 100,000.]

	Color.	Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
					Albuminoid.							
		Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		
Average of 4 samples collected in 1902,	.06	4.04	1.53	.0022	.0225	.0187	.0038	.45	.0032	.0001	.27	1.5
Average of ten previous years, . .	.09	4.21	1.30	.0012	.0217	.0183	.0034	.47	.0049	.0000	.26	1.7

Odor in 1902, frequently faintly vegetable.

North Branch of Millham Brook, near its Entrance to the Millham Brook Storage Reservoir.

Average of 12 samples collected in 1902,	1.11	5.14	2.19	.0040	.0252	.0218	.0034	.34	.0075	.0001	.89	1.0
Average of six previous years, . .	1.15	5.45	2.30	.0029	.0271	.0239	.0032	.34	.0085	.0001	.99	1.3

Odor in 1902, faintly vegetable, becoming stronger on heating.

MARLBOROUGH.

Millham Brook, near its Entrance to the Millham Brook Storage Reservoir.

[Parts per 100,000.]

	Color.	Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Total.	Loss on Ignition.	Free.	Albuminoid.				Nitrates.	Nitrites.			
					Total.	Dissolved.	Suspended.						
Average of 12 samples collected in 1902.	0.48	5.30	2.00	.0041	.0196	.0172	.0024	0.38	.0185	.0001	.55	1.7	-
Average of six previous years, .	0.52	5.32	1.97	.0022	.0192	.0174	.0018	0.39	.0173	.0001	.58	1.9	-

Odor in 1902, vegetable or unpleasant, becoming stronger on heating.

Millham Brook Storage Reservoir, at Surface.

Average of 12 samples collected in 1902.	0.41	3.89	1.67	.0054	.0239	.0187	.0052	0.31	.0102	.0001	.51	1.1	-
Average of six previous years, .	0.60	4.09	1.70	.0052	.0297	.0229	.0068	0.29	.0080	.0001	.58	1.3	-

Odor in 1902, vegetable or distinctly unpleasant, becoming stronger on heating. A very large number of organisms was present in the samples collected between the months of April and September.

Millham Brook Storage Reservoir, at Bottom.

Average of 12 samples collected in 1902.	0.79	4.45	1.91	.0424	.0273	.0213	.0060	0.31	.0085	.0001	.62	1.3	-
Average of six previous years, .	1.05	4.83	1.95	.0327	.0342	.0252	.0090	0.30	.0078	.0002	.68	1.4	-

Odor in 1902, vegetable or faintly unpleasant, becoming stronger on heating.

WATER SUPPLY OF MARSHFIELD. — BRANT ROCK WATER COMPANY.

Well.

August, 1902, ...	0.00	12.00	-	.0006	.0004	-	-	3.70	.0420	.0000	.05	2.0	.0050

WATER SUPPLY OF MAYNARD.

White Pond.

Average of 4 samples collected in 1902.	0.04	3.26	1.17	.0006	.0106	.0089	.0017	0.29	.0032	.0000	.14	0.7	-
Average of ten previous years, .	0.04	2.41	0.89	.0004	.0142	.0119	.0023	0.29	.0019	.0000	.16	0.6	-

Odor in 1902, frequently faintly vegetable or unpleasant.

WATER SUPPLY OF MEDFIELD.

Spring.

Average of 2 samples collected in 1902.	0.00	4.40	-	.0015	.0042	-	-	0.22	.0025	.0000	.03	1.4	.0055

WATER SUPPLY OF MEDFIELD INSANE ASYLUM.

Farm Pond in Sherborn.

[Parts per 100,000.]

	Color.	Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
					Albuminoid.								
		Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.			
Average of 4 samples collected in 1902.	.01	1.81	0.81	.0014	.0105	.0095	.0010	.21	.0025	.0000	.14	0.4	-
Average of four previous years, .	.04	1.91	0.81	.0008	.0121	.0112	.0009	.24	.0018	.0000	.14	0.2	-

WATER SUPPLY OF MEDFORD.

(See *Metropolitan Water District*, pages 95–99.)

WATER SUPPLY OF MELROSE.

(See *Metropolitan Water District*, pages 95–99.)

WATER SUPPLY OF METHUEN.

Tubular Wells.

Average of 6 samples collected in 1902.	.11	7.32	-	.0007	.0056	-	-	.32	.0193	.0000	.08	3.2	.0095
Average of eight previous years, .	.06	7.33	-	.0002	.0037	-	-	.30	.0131	.0001	.09	3.1	.0099

WATER SUPPLY OF MIDDLEBOROUGH FIRE DISTRICT.

Well.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1902.												
38881	Feb. 5	None.	None.	.07	6.60	.0016	.0022	.71	.1080	.0001	.03	2.9	.0500
39526	Apr. 2	V. slight.	Cons.	.08	6.20	.0010	.0022	.68	.1140	.0000	.08	2.5	.0450
40337	June 4	Decided.	Cons.	.33	6.00	.0032	.0064	.58	.0210	.0001	.23	2.0	.1000
41520	Aug. 6	Decided.	V. slight.	.35	6.70	.0012	.0084	.57	.0280	.0002	.23	1.8	.1200
42048	Sept. 3	Decided.	Cons.	-	6.20	.0036	.0082	.56	.0200	.0000	.16	1.8	.0850
42533	Oct. 1	Decided.	Slight.	-	6.00	.0016	.0066	.60	.0200	.0001	.19	2.0	.1100
42749	Oct. 16	Decided.	Slight.	.40	5.80	.0032	.0060	.60	.0300	.0001	.23	2.0	.1500
43033	Nov. 5	Decided.	Cons.	.19	6.00	.0046	.0050	.64	.0380	.0000	.17	2.0	.0950
43363	Dec. 1	V. slight.	Cons.	.02	6.30	.0026	.0042	.62	.0380	.0000	.17	2.3	.0600
43412	Dec. 3	Slight.	Cons.	.20	6.70	.0044	.0048	.62	.0380	.0001	.20	2.2	.0350

MIDDLEBOROUGH FIRE DISTRICT.

Well — Concluded.

Averages by Years.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
-	1888	-	-	.00	8.67	.0001	.0025	.96	.1494	.0001	-	-	-
-	1895	-	-	.06	6.74	.0001	.0028	.74	.0687	.0000	.08	2.6	.0187
-	1896	-	-	.18	6.54	.0003	.0038	.72	.0565	.0000	.09	2.4	.0288
-	1897	-	-	.09	6.28	.0006	.0039	.71	.0580	.0000	.11	2.5	.0227
-	1898	-	-	.16	6.78	.0008	.0044	.75	.0687	.0001	.14	2.7	.0408
-	1899	-	-	.15	6.54	.0010	.0037	.69	.0684	.0000	.12	2.3	.0329
-	1900	-	-	.15	5.99	.0012	.0037	.69	.0592	.0000	.10	2.2	.0489
-	1901	-	-	.19	6.47	.0014	.0053	.67	.0762	.0000	.12	2.3	.0487
-	1902*	-	-	.22	6.26	.0026	.0054	.62	.0490	.0001	.16	2.1	.0841

* Where more than one sample was collected in a month, the mean analysis for that month has been used in making the average.

WATER SUPPLY OF MIDDLETON.

(See *Danvers.*)

WATER SUPPLY OF MILFORD AND HOPEDALE. — MILFORD WATER COMPANY. (See also page 29.)

Wells.

[Parts per 100,000.]

	Color.	Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
					Albuminoid.								
		Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.			
Average of 5 samples collected in 1902.	.18	3.82	-	.0008	.0074	-	-	.27	.0172	.0000	.26	1.0	.0156
Average of four previous years, .	.09	3.51	-	.0007	.0062	-	-	.26	.0158	.0000	.18	1.0	.0185

The samples represent water from the wells mingled with water from the river which has passed through the sand filters.

Charles River, above Milford.

Average of 5 samples collected in 1902.	.49	3.88	1.76	.0023	.0196	.0168	.0028	.26	.0108	.0001	.60	0.8	-
Average of two previous years, .	.43	3.74	1.78	.0033	.0228	.0202	.0026	.25	.0066	.0000	.60	0.5	-

Odor in 1902, faintly vegetable, becoming stronger on heating.

WATER SUPPLY OF MILLBURY. — MILLBURY WATER COMPANY.

Well.

Average of 6 samples collected in 1902.	.01	5.15	-	.0002	.0017	-	-	.23	.0272	.0000	.02	2.1	.0048
Average of five previous years, .	.02	5.09	-	.0007	.0023	-	-	.23	.0218	.0001	.03	2.4	.0071

WATER SUPPLY OF MILLIS.

Aqua Rex Spring.

[Parts per 100,000.]

		RESIDUE ON EVAPORATION.		AMMONIA.					NITROGEN AS				
					ALBUMINOID.								
	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Sus-pended.	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Hardness.	Iron.
July, 1902, ...	.00	7.00	-	.0006	.0020	-	-	.59	.1900	.0000	.01	3.0	.0080

WATER SUPPLY OF MILTON. (See also pages 30–32.)

(See *Metropolitan Water District*, pages 95–99, and *Hyde Park*, page 122.)

The water supply of Milton was obtained from the Hyde Park Water Company until March 1. From that time until August 22 water for the low-service district was obtained from the Metropolitan Water District, and since August 22 the entire supply has been obtained from the Metropolitan District.

Water examined in Connection with Advice to Oliver H. Flanders. (See also page 32.)

[Parts per 100,000.]

		APPEARANCE.				AMMONIA.			NITROGEN AS				
Number.	Date of Collection.	Turbidity.	Sediment.	Color.	Residue on Evaporation.	Free.	Albu-minoid.	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Hardness.	Iron.
38866	**1902.** Feb. 4	None.	None.	.01	8.00	.0006	.0006	.55	.0230	.0000	.01	3.4	.0060

The sample was collected from a faucet in the house of O. H. Flanders, supplied from a well in East Milton.

WATER SUPPLY OF MONSON.

Well.

[Parts per 100,000.]

		RESIDUE ON EVAPORATION.		AMMONIA.					NITROGEN AS				
					ALBUMINOID.								
	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Sus-pended.	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Hardness.	Iron.
Average of 6 samples collected in 1902.	.00	3.23	-	.0001	.0010	-	-	.11	.0090	.0000	.01	1.0	.0072
Average of six previous years, .	.00	3.77	-	.0002	.0012	-	-	.12	.0084	.0000	.02	1.1	.0077

MONTAGUE.

WATER SUPPLY OF MONTAGUE. — TURNER'S FALLS FIRE DISTRICT.

Lake Pleasant.

[Parts per 100,000.]

		RESIDUE ON EVAPORATION.		AMMONIA.					NITROGEN AS				
					ALBUMINOID.								
	Color.	Total.	Loss on ignition.	Free.	Total.	Dissolved.	Sus-pended.	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Hardness.	Iron.
Average of 4 samples collected in 1902.	.04	3.40	0 95	.0015	.0071	.0061	.0010	.11	.0027	.0000	.10	0.4	-
Average of nine previous years, .	.04	2.27	0.72	.0019	.0091	.0074	.0017	.12	.0035	.0000	.11	0.4	-

Odor in February, 1902, unpleasant.

Waters examined in Connection with Advice to the Miller's Falls Company. (See also page 32.)

[Parts per 100,000.]

		APPEARANCE.				AMMONIA.			NITROGEN AS				
Number.	Date of Collection.	Turbidity.	Sediment.	Color.	Residue on Evaporation.	Free.	Albu-minoid.	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Hardness.	Iron.
	1902.												
38836	Feb. 3	None.	V. slight.	.00	8.00	.0000	.0020	.38	.1700	.0000	.02	2.9	.0050
38760	Jan. 23	None.	V. slight.	.02	3.70	.0000	.0004	.16	.0050	.0000	.02	1.0	.0100

The first sample was collected from a tubular well on the premises of the Miller's Falls Company, formerly used as a source of supply for the factory and a considerable number of houses in the village; the last, from a new 6-inch tubular well beneath the lower mill of the Miller's Falls Company.

WATER SUPPLY OF NAHANT.

(See *Metropolitan Water District*, pages 95-99.)

WATER SUPPLY OF NANTUCKET. — WANNACOMET WATER COMPANY.

Wannacomet Pond.

[Parts per 100,000.]

		APPEARANCE.			RESIDUE ON EVAPORATION.		AMMONIA.					NITROGEN AS			
								ALBUMINOID.							
Number.	Date of Collection.	Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Sus-pended.	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Hardness.
	1902.														
39956	May 6	V. slight.	Slight.	.01	6.10	1.70	.0006	.0152	.0114	.0038	2.28	.0020	.0000	.10	1.1
40789	June 24	None.	Slight.	.02	6.10	1.75	.0032	.0172	.0118	.0054	2.27	.0020	.0000	.10	1.4
42436	Sept. 23	Decided.	Cons.	.21	9.00	3.00	.0040	.0444	.0216	.0228	2.45	.0010	.0000	.17	1.4
43574	Dec. 23	V. slight.	Cons.	.01	7.00	2.75	.0140	.0186	.0154	.0032	2.30	.0020	.0000	.18	1.3
Av...	....	....	....	.06	7.05	2.30	.0054	.0238	.0150	.0088	2.32	.0017	.0000	.14	1.3
Average of eleven previous years, .				.10	6.85	1.79	.0031	.0252	.0159	.0093	2.26	.0024	.0000	.15	1.6

Odor during the latter part of 1902, unpleasant. The organism *Anabœna* was present in large numbers in the sample collected in September, and was found in the sample collected in December.

Wells near Wannacomet Pond.

[Parts per 100,000.]

	Color.	Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
					Albuminoid.								
		Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.			
Average of 3 samples collected in 1902.	0.06	7.30	-	.0062	.0065	-	-	2.21	.0123	.0001	0.10	1.7	.0223
Average of 6 samples collected in 1901.	0.00	6.47	-	.0049	.0032	-	-	2.25	.0158	.0001	0.04	1.4	.0093

Water Supply of Natick. (See also page 33.)

Dug Pond.

Average of 5 samples collected in 1902.	0.13	4.89	1.82	.0054	.0176	.0155	.0021	0.52	.0116	.0001	0.26	2.1	-
Average of eleven previous years,	0.12	5.48	1.53	.0056	.0187	.0159	.0028	0.72	.0211	.0002	0.25	2.2	-

Odor in 1902, generally distinctly unpleasant.

Water Supply of Needham.

Well No. 1.

Average of 6 samples collected in 1902.	0.00	5.55	-	.0002	.0014	-	-	0.57	.1405	.0000	0.02	1.8	.0055
Average of eight previous years,	0.00	6.10	-	.0002	.0009	-	-	0.73	.1675	.0000	0.02	2.0	.0017

Well No. 2.

Average of 6 samples collected in 1902.	0.00	6.22	-	.0001	.0011	-	-	0.58	.1550	.0000	0.01	2.0	.0052
Average of two previous years, .	0.00	6.96	-	.0004	.0020	-	-	0.68	.2180	.0001	0.01	2.5	.0041

Water Supply of New Bedford.

Old Storage Reservoir.

Average of 4 samples collected in 1902.	0.97	4.62	2.11	.0032	.0266	.0232	.0034	0.52	.0025	.0000	0.99	0.8	-
Average of ten previous years, .	1.11	4.74	2.27	.0017	.0233	.0203	.0030	0.52	.0062	.0000	1.03	1.0	-

Odor in 1902, vegetable, becoming stronger on heating. The organism *Anabæna* was present in the sample collected in August.

NEW BEDFORD.

Little Quittacas Pond, in Lakeville.

[Parts per 100,000.]

	Color.	Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Total.	Loss on Ignition.	Free.	Albuminoid.				Nitrates.	Nitrites.			
					Total.	Dissolved.	Suspended.						
Average of 12 samples collected in 1902.	0.25	3.31	1.62	.0017	.0165	.0145	.0020	.48	.0012	.0000	.45	0.7	-
Average of nine previous years, .	0.19	3.20	1.25	.0008	.0177	.0149	.0028	.51	.0020	.0000	.35	0.7	-

Odor in 1902, frequently faintly vegetable, becoming stronger on heating.

Great Quittacas Pond, in Lakeville.

Average of 4 samples collected in 1902.	0.41	3.27	1.69	.0017	.0177	.0147	.0030	.47	.0005	.0000	.60	0.6	-
Average of nine previous years, .	0.48	3.54	1.56	.0005	.0174	.0153	.0021	.52	.0013	.0000	.60	0.6	-

Odor in 1902, vegetable or unpleasant.

Faucet in City Hall.

Average of 12 samples collected in 1902.	0.24	3.20	1.47	.0016	.0167	.0147	.0020	.47	.0012	.0000	.45	0.6	-
Average of three previous years,	0.20	3.33	1.40	.0013	.0179	.0162	.0017	.49	.0014	.0000	.39	0.7	-

Odor in 1902, frequently faintly vegetable, becoming stronger on heating.

WATER SUPPLY OF NEWBURYPORT.

Wells.

Average of 6 samples collected in 1902.	0.08	5.80	-	.0004	.0048	-	-	.47	.0232	.0000	.10	2.1	.0343
Average of nine previous years, .	0.12	6.45	-	.0005	.0041	-	-	.66	.0200	.0000	.09	2.5	.0272

WATER SUPPLY OF NEWTON.

Wells and Filter Gallery.

Average of 8 samples collected in 1902.	0.04	5.84	-	.0006	.0032	-	-	.45	.0436	.0000	.06	2.4	.0057
Average of ten previous years, .	0.03	5.75	-	.0004	.0027	-	-	.42	.0271	.0000	.07	2.5	.0083

Water Supply of North Adams.

Notch Brook Storage Reservoir.

[Parts per 100,000.]

		Residue on Evaporation.		Ammonia.					Nitrogen as				
					Albuminoid.								
	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Hardness.	Iron.
Average of 4 samples collected in 1902.	.04	6.22	1.25	.0032	.0096	.0080	.0016	.06	.0022	.0002	.15	4.6	-
Average of six previous years, .	.05	7.52	1.29	.0027	.0084	.0063	.0021	.07	.0039	.0000	.13	5.6	-

Broad Brook, in Pownal, Vt.

Average of 4 samples collected in 1902.	.29	3.40	1.50	.0020	.0104	.0081	.0023	.06	.0190	.0000	.46	1.4	-
Average of six previous years, .	.15	4.34	1.27	.0008	.0077	.0061	.0016	.07	.0142	.0000	.29	2.6	-

Odor in 1902, occasionally faintly vegetable.

Water Supply of Northampton.

Middle Storage Reservoir on Roberts' Meadow Brook.

Average of 4 samples collected in 1902.	.20	3.90	1.34	.0011	.0112	.0094	.0018	.11	.0030	.0000	.33	1.4	-
Average of six previous years, .	.26	3.90	1.35	.0011	.0135	.0109	.0026	.10	.0033	.0000	.38	1.5	-

Odor in August, 1902, faintly unpleasant, becoming stronger on heating.

West Brook, in Whately.

Average of 12 samples collected in 1902.	.13	3.78	1.15	.0009	.0063	.0051	.0012	.09	.0037	.0000	.24	1.7	-

Odor, occasionally faintly vegetable.

Water Supply of North Andover.

Great Pond.

Average of 4 samples collected in 1902.	.14	3.22	1.42	.0015	.0179	.0159	.0020	.32	.0032	.0000	.32	1.1	-
Average of three previous years,	.11	3.39	1.21	.0017	.0194	.0172	.0022	.32	.0020	.0000	.33	1.2	-

Odor in 1902, generally vegetable. The organism *Uroglena* was present in the sample collected in September.

NORTH ATTLEBOROUGH.

WATER SUPPLY OF NORTH ATTLEBOROUGH.

Well.

[Parts per 100,000.]

		Residue on Evaporation.		Ammonia.					Nitrogen as				
					Albuminoid.								
	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Hardness.	Iron.
Average of 7 samples collected in 1902.	.01	6.37	-	.0004	.0019	-	-	.67	.0541	.0000	.05	3.0	.0087
Average of ten previous years, .	.01	6.57	-	.0004	.0013	-	-	.66	.0481	.0000	.02	3.0	.0081

WATER SUPPLY OF NORTHBOROUGH.

Lower Reservoir.

Average of 4 samples collected in 1902.	.65	3.82	1.77	.0025	.0204	.0168	.0036	.21	.0065	.0000	.70	0.7	-
Average of six previous years, .	.66	3.70	1.61	.0020	.0227	.0196	.0031	.21	.0038	.0000	.69	0.9	-

Odor in 1902, faintly vegetable, becoming stronger on heating.

WATER SUPPLY OF NORTHBRIDGE. — WHITIN MACHINE WORKS.

Spring No. 2.

Average of 4 samples collected in 1902.	.12	3.81	-	.0028	.0063	-	-	.32	.0217	.0000	.17	0.7	.0103
Average of 9 samples collected in 1901.	.09	2.97	-	.0002	.0053	-	-	.25	.0169	.0000	.19	0.6	.0052

Odor in October, 1902, vegetable.

Spring No. 3.

Average of 4 samples collected in 1902.	.11	3.10	-	.0007	.0050	-	-	.19	.0020	.0000	.22	0.6	.0073
Average of 4 samples collected in 1901.	.12	3.45	-	.0000	.0060	-	-	.19	.0075	.0000	.25	0.9	.0072

Cook Allen Brook.

Average of 4 samples collected in 1902.	.32	3.06	1.25	.0011	.0107	.0089	.0018	.18	.0015	.0000	.48	0.3	-

Odor in July, distinctly unpleasant.

WATER SUPPLY OF NORTH BROOKFIELD.

Doane Pond.

Average of 4 samples collected in 1902.	.49	3.16	1.46	.0043	.0230	.0180	.0050	.14	.0047	.0002	.50	0.3	-
Average of eight previous years, .	.56	3.67	1.53	.0068	.0297	.0244	.0053	.16	.0055	.0001	.52	0.9	-

Odor in 1902, vegetable or unpleasant. A large number of organisms was found in the sample collected in January, consisting chiefly of *Peridinium*.

NORTH BROOKFIELD.

North Pond.

[Parts per 100,000.]

	Color.	Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Total.	Loss on Ignition.	Free.	Albuminoid.				Nitrates.	Nitrites.			
					Total.	Dissolved.	Suspended.						
Average of 4 samples collected in 1902.	.53	3.40	1.54	.0038	.0255	.0207	.0048	.15	.0032	.0000	.63	0.4	-
Average of five previous years, .	.51	3.47	1.58	.0054	.0310	.0245	.0065	.15	.0063	.0001	.60	0.7	-

Odor in 1902, generally vegetable and occasionally unpleasant. The organism *Anabæna* was present in the sample collected in August.

WATER SUPPLY OF NORTHFIELD. — NORTHFIELD WATER COMPANY.

Reservoir.

Average of 4 samples collected in 1902.	.18	2.81	1.05	.0004	.0068	.0050	.0018	.07	.0017	.0000	.29	0.7	-
Average of two previous years, .	.16	2.96	0.96	.0003	.0068	.0062	.0006	.10	.0026	.0000	.30	0.7	-

In 1902, a faintly vegetable odor was developed in several of the samples, when heated. The organism *Anabæna* was present in the sample collected in August.

NORTON.

Water examined in Connection with Advice to the Town Authorities. (See also page 34.)

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1902.												
39921	May 5	None.	None.	.05	4.20	.0014	.0118	.22	.1050	.0000	.28	2.9	.0080

The sample was collected from a well on the southerly side of Main Street, west of the Unitarian church.

WATER SUPPLY OF NORWOOD.

Buckmaster Pond in Dedham.

[Parts per 100,000.]

	Color.	Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Total.	Loss on Ignition.	Free.	Albuminoid.				Nitrates.	Nitrites.			
					Total.	Dissolved	Suspended.						
Average of 12 samples collected in 1902.	.10	2.92	1.15	.0069	.0158	.0137	.0021	.34	.0035	.0001	.23	0.6	-
Average of eleven previous years,	.12	2.85	1.13	.0051	.0201	.0164	.0037	.33	.0047	.0000	.27	0.6	-

Odor in 1902, generally faintly vegetable or unpleasant, becoming stronger on heating.

ORANGE.

WATER SUPPLY OF ORANGE.

Distributing Reservoir.

[Parts per 100,000.]

		Residue on Evaporation.		Ammonia.					Nitrogen as				
					Albuminoid.								
	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Hardness.	Iron.
Average of 4 samples collected in 1902.	.03	3.09	1.13	.0014	.0104	.0077	.0027	.09	.0017	.0000	.21	0.6	-
Average of eight previous years, .	.16	3.11	0.96	.0007	.0086	.0071	.0015	.13	.0027	.0000	.24	0.6	-

Odor in 1902, generally vegetable or unpleasant. The organism *Dinobryon* was present in large numbers in the sample collected in March.

WATER SUPPLY OF PALMER FIRE DISTRICT. — PALMER WATER COMPANY.

Lower Reservoir.

	Color.	Residue on Evaporation: Total.	Residue on Evaporation: Loss on Ignition.	Ammonia: Free.	Albuminoid: Total.	Albuminoid: Dissolved.	Albuminoid: Suspended.	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Hardness.	Iron.
Average of 4 samples collected in 1902.	.25	3.65	1.37	.0014	.0156	.0129	.0027	.12	.0015	.0000	.34	0.7	-
Average of five previous years, .	.28	3.39	1.11	.0008	.0144	.0119	.0025	.13	.0031	.0000	.32	0.7	-

Odor in 1902, generally vegetable or unpleasant. The organism *Synura* was present in the samples collected in March and September.

Water examined in Connection with Advice to the Town Authorities. (See also page 34.)

[Parts per 100,000.]

		Appearance.				Ammonia.			Nitrogen as				
Number.	Date of Collection.	Turbidity.	Sediment.	Color.	Residue on Evaporation.	Free.	Albuminoid.	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Hardness.	Iron.
	1902.												
38761	Jan. 24	V. slight.	Cons.	.09	3.60	.0014	.0066	.11	.0080	.0000	.13	0.5	.0080
38804	Jan. 30	V. slight.	Slight.	.04	3.15	.0000	.0044	.11	.0050	.0000	.10	0.8	.0040

The first sample was collected from a spring in Monson, supplying several houses in Palmer; the last, from a faucet in a house supplied from this spring.

WATER SUPPLY OF PEABODY.

Brown's Pond.

[Parts per 100,000.]

		Residue on Evaporation.		Ammonia.					Nitrogen as			
					Albuminoid.							
	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Hardness.
Average of 4 samples collected in 1902,	.16	3.17	1.35	.0019	.0160	.0134	.0026	.50	.0037	.0000	.28	0.6
Average of seven previous years, . .	.15	2.96	1.17	.0009	.0169	.0144	.0025	.55	.0039	.0000	.29	0.6

Odor in 1902, vegetable or unpleasant when heated.

PEABODY.

Spring Pond.

[Parts per 100,000.]

		Residue on Evaporation.		Ammonia.					Nitrogen as			
					Albuminoid.							
	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Sus-pended.	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Hardness.
Average of 4 samples collected in 1902,	.05	3.80	1.46	.0025	.0145	.0111	.0034	.60	.0005	.0000	.17	1.4
Average of eight previous years, . .	.03	3.87	1.16	.0035	.0145	.0115	.0030	.68	.0022	.0000	.17	1.4

Odor in 1902, generally faintly vegetable or unpleasant.

PEMBROKE.

Oldham Pond.

Average of 4 samples collected in 1902,	.29	3.90	1.62	.0017	.0245	.0193	.0052	.56	.0030	.0001	.42	0.5
Average of four previous years, . .	.29	3.63	1.38	.0013	.0215	.0182	.0033	.61	.0019	.0000	.42	0.5

Odor in 1902, vegetable or unpleasant. This pond is not used as a source of water supply.

WATER SUPPLY OF PITTSFIELD.

Sacket Brook Reservoir.

Average of 4 samples collected in 1902,	.12	5.41	1.61	.0028	.0094	.0084	.0010	.08	.0112	.0001	.21	3.8
Average of six previous years, . .	.11	6.56	1.44	.0014	.0113	.0099	.0014	.09	.0113	.0000	.20	5.1

Ashley Brook Reservoir.

Average of 4 samples collected in 1902,	.20	5.34	2.09	.0059	.0199	.0171	.0028	.09	.0057	.0000	.33	3.8
Average of six previous years, . .	.15	6.38	1.69	.0019	.0125	.0109	.0016	.09	.0103	.0000	.26	4.8

Hathaway Brook Reservoir.

Average of 4 samples collected in 1902,	.06	7.81	2.15	.0025	.0089	.0072	.0017	.10	.0142	.0000	.17	5.5
Average of six previous years, . .	.06	8.35	1.81	.0007	.0079	.0068	.0011	.10	.0149	.0000	.13	7.0

Mill Brook Reservoir.

Average of 4 samples collected in 1902,	.05	4.35	1.37	.0003	.0053	.0047	.0006	.06	.0072	.0000	.14	2.9
Average of six previous years, . .	.04	5.15	1.01	.0010	.0063	.0052	.0011	.08	.0089	.0000	.11	3.6

PLYMOUTH.

WATER SUPPLY OF PLYMOUTH.

Little South Pond.

[Parts per 100,000.]

	Color.	Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
					Albuminoid.								
		Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.			
Average of 5 samples collected in 1902.	.02	2.63	0.98	.0015	.0127	.0112	.0015	.67	.0008	.0000	.13	0.1	-
Average of eight previous years, .	.02	2.50	0.83	.0009	.0150	.0129	.0021	.69	.0016	.0000	.12	0.1	-

Odor in March and December, 1902, unpleasant; at other times, generally vegetable. The organism *Anabœna* was present in large numbers in the samples collected in June and September, and *Uroglena* in the sample collected in March.

Water examined in Connection with Advice to the Town Authorities. (See also page 35.)

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
36913	1901. Aug. 23	V. slight.	None.	.01	14.50	.0004	.0022	2.77	.1920	.0001	.01	4.2	.0030
37213	Sept. 13	None.	None.	.00	15.70	.0000	.0016	2.91	.2400	.0001	.03	4.9	.0160
37505	Oct. 8	None.	None.	.00	15.40	.0000	.0016	2.94	.2200	.0002	.02	5.3	.0050
39013	1902. Feb. 13	None.	None.	.00	14.40	.0006	.0018	2.85	.3600	.0000	.01	5.0	.0070

The samples were collected from a spring on Water Street near the foot of Chilton Street.

WATER SUPPLY OF PROVINCETOWN.

Open Basin.

[Parts per 100,000.]

	Color.	Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
					Albuminoid.								
		Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.			
Average of 6 samples collected in 1902.	-	10.33	-	.0110	.0176	-	-	2.60	.0062	.0001	.75	2.5	.4100
Average of four previous years, .	.92	10.49	-	.0124	.0183	-	-	2.58	.0055	.0001	.71	2.5	.3576

Odor in June, 1902, distinctly unpleasant.

WATER SUPPLY OF QUINCY.

(See *Metropolitan Water District*, pages 95-99.)

WATER SUPPLY OF RANDOLPH AND HOLBROOK.

Great Pond in Randolph and Braintree.

[Parts per 100,000]

		Residue on Evaporation.		Ammonia.					Nitrogen as				
					Albuminoid.								
	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Hardness.	Iron.
Average of 6 samples collected in 1902.	.34	3.77	1.44	.0012	.0154	.0141	.0013	.52	.0043	.0000	.50	0.9	-
Average of eight previous years, .	.46	4.05	1.65	.0009	.0193	.0172	.0021	.54	.0042	.0000	.53	1.0	-

Odor in 1902, frequently faintly vegetable, becoming stronger on heating.

WATER SUPPLY OF READING.

Filter Gallery.

[Parts per 100,000.]

		Appearance.				Ammonia.			Nitrogen as				
Number.	Date of Collection.	Turbidity.	Sediment.	Color.	Residue on Evaporation.	Free.	Albuminoid.	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Hardness.	Iron.
	1902.												
38980	Feb. 11	Decided.	Cons.	0.65	8.90	.0082	.0096	.40	.0100	.0000	.49	4.0	.1900
39548	Apr. 6	Decided.	Cons.	0.55	6.50	.0080	.0112	.37	.0070	.0002	.57	2.0	.0800
40368	June 9	Decided.	Cons.	1.05	7.50	.0088	.0132	.41	.0060	.0000	.74	3.1	.1400
41577	Aug. 12	Decided.	Cons.	0.70	7.80	.0106	.0122	.43	.0020	.0001	.52	1.8	.1400
42720	Oct. 14	Decided.	Cons.	0.60	7.70	.0112	.0086	.47	.0010	.0000	.55	2.9	.0800
43487	Dec. 14	Decided.	Cons.	0.70	8.70	.0118	.0130	.51	.0030	.0000	.40	3.1	.1900

Averages by Years.

-	1891	-	-	0.13	12.96	.0016	.0063	.43	.0094	.0001	-	5.1	-
-	1892	-	-	0.44	9.25	.0042	.0073	.54	.0071	.0001	-	3.4	-
-	1893	-	-	0.64	10.08	.0034	.0087	.56	.0032	.0001	.35	3.9	.1251
-	1894	-	-	0.45	12.76	.0043	.0107	.68	.0029	.0000	.35	5.0	.2642
-	1895	-	-	0.61	13.88	.0088	.0114	.72	.0048	.0000	.44	5.5	.2277
-	1896	-	-	0.52	11.50	.0080	.0089	.51	.0059	.0001	.40	4.1	.2696
-	1897	-	-	0.76	11.12	.0090	.0110	.53	.0058	.0001	.44	4.0	.2644
-	1898	-	-	0.82	9.61	.0095	.0141	.44	.0003	.0000	.64	3.0	.2254
-	1899	-	-	0.67	7.80	.0099	.0109	.44	.0025	.0000	.50	2.4	.1721
-	1900	-	-	0.59	9.27	.0105	.0098	.45	.0041	.0000	.43	2.9	.2497
-	1901	-	-	0.65	9.33	.0087	.0121	.43	.0058	.0000	.58	3.3	.2068
-	1902	-	-	0.71	7.85	.0098	.0113	.43	.0048	.0000	.54	2.8	.1367

READING.

Water of Filter Gallery after passing through the Mechanical Filter.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1902.												
38981	Feb. 11	None.	None.	.22	15.50	.0050	.0060	.42	.0070	.0003	.34	9.1	.0160
39549	Apr. 6	None.	None.	.21	14.50	.0060	.0072	.39	.0060	.0005	.42	8.6	.0080
40369	June 9	V. slight.	None.	.31	15.70	.0082	.0080	.41	.0050	.0003	.40	9.6	.0070
41578	Aug. 12	None.	None.	.26	15.00	.0086	.0086	.44	.0010	.0003	.36	7.3	.0180
42721	Oct. 14	None.	None.	.22	15.60	.0064	.0060	.48	.0020	.0009	.45	8.7	.0060
43488	Dec. 14	None.	None.	.25	15.90	.0070	.0090	.48	.0040	.0006	.23	9.6	.0100

Averages by Years.

Number.	Date of Collection.	Turbidity.	Sediment.	Color.	Residue on Evaporation.	Ammonia, Free.	Ammonia, Albuminoid.	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Hardness.	Iron.
-	1896	-	-	.15	19.42	.0035	.0067	.56	.0043	.0016	.24	11.3	.0091
-	1897	-	-	.23	18.54	.0034	.0084	.52	.0082	.0010	.29	12.7	.0037
-	1898	-	-	.27	16.82	.0028	.0103	.45	.0060	.0006	.34	10.0	.0132
-	1899	-	-	.23	14.60	.0040	.0080	.45	.0042	.0016	.32	8.4	.0084
-	1900	-	-	.14	14.59	.0053	.0073	.47	.0046	.0015	.25	7.9	.0082
-	1901	-	-	.21	16.05	.0073	.0098	.46	.0049	.0012	.33	9.1	.0150
-	1902	-	-	.24	15.37	.0069	.0075	.44	.0042	.0005	.37	8.8	.0108

WATER SUPPLY OF REVERE.

(See *Metropolitan Water District*, pages 95–99.)

WATER SUPPLY OF ROCKLAND.

(See *Abington.*)

WATER SUPPLY OF ROCKPORT. (See also page 35.)

Cape Pond.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		
	1902.														
39411	Mar. 24	V. slight.	Cons.	.28	8.85	3.65	.0014	.0226	.0168	.0058	3.31	.0030	.0000	.46	1.0
40676	June 23	V. slight.	Slight.	.28	9.00	2.00	.0016	.0222	.0190	.0032	3.44	.0100	.0001	.25	1.4
42396	Sept. 23	Decided.	Cons.	.30	9.15	2.55	.0056	.0332	.0236	.0096	3.46	.0060	.0002	.35	1.3
43572	Dec. 23	V. slight.	V. slight.	.39	9.50	2.70	.0062	.0226	.0178	.0048	3.59	.0030	.0000	.50	1.7

Averages by Years.

Number.	Date of Collection.	Turbidity.	Sediment.	Color.	Residue, Total.	Residue, Loss on Ignition.	Ammonia, Free.	Albuminoid, Total.	Albuminoid, Dissolved.	Albuminoid, Suspended.	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Hardness.
-	1894	-	-	.22	12.85	1.91	.0001	.0225	.0163	.0062	5.55	.0010	.0000	.25	1.3
-	1895	-	-	.25	12.61	2.31	.0025	.0302	.0198	.0104	5.42	.0037	.0000	.32	1.2
-	1896	-	-	.29	11.67	2.11	.0008	.0198	.0149	.0049	4.97	.0039	.0000	.24	1.0
-	1897	-	-	.30	10.94	2.10	.0034	.0251	.0196	.0055	4.60	.0058	.0000	.31	1.1
-	1898	-	-	.44	10.43	2.17	.0049	.0336	.0231	.0105	4.34	.0025	.0001	.38	1.0
-	1899	-	-	.35	10.21	2.06	.0040	.0308	.0230	.0078	4.24	.0043	.0001	.39	0.8
-	1900	-	-	.17	9.75	1.71	.0025	.0343	.0206	.0137	4.11	.0017	.0000	.34	1.1
-	1901	-	-	.29	10.37	2.35	.0180	.0322	.0242	.0080	3.94	.0038	.0002	.43	1.3
-	1902	-	-	.31	9.12	2.72	.0037	.0251	.0193	.0058	3.45	.0055	.0001	.39	1.3

Odor in 1902, vegetable or unpleasant.

The organism *Anabœna* was present in enormous numbers in the samples collected in August and September.

WATER SUPPLY OF RUTLAND.

Muschopauge Lake.

[Parts per 100,000.]

	Color.	Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Total.	Loss on Ignition.	Free.	Albuminoid.				Nitrates.	Nitrites.		
					Total.	Dissolved.	Sus-pended.					
Average of 4 samples collected in 1902,	0.09	2.35	0.94	.0014	.0121	.0099	.0022	.16	.0015	.0000	.21	0.3
Average of five previous years, . .	0.05	2.25	0.84	.0030	.0156	.0131	.0025	.17	.0028	.0000	.16	0.5

Odor in 1902, frequently faintly vegetable or unpleasant.

WATER SUPPLY OF SALEM AND BEVERLY.

Wenham Lake, in Beverly and Wenham.

Average of 12 samples collected in 1902,	0.10	5.48	1.85	.0050	.0201	.0152	.0049	.75	.0059	.0002	.29	2.3
Average of eleven previous years, .	0.11	5.69	1.54	.0030	.0173	.0137	.0036	.77	.0060	.0001	.26	2.5

Odor in 1902, faintly vegetable or unpleasant, becoming stronger on heating. The organisms *Anabæna* and *Cœlosphærium* were present in large numbers in the samples collected in August, September and October.

Longham Brook, in Beverly and Wenham.

Average of 9 samples collected in 1902,	0.90	5.77	2.54	.0066	.0293	.0258	.0035	.88	.0178	.0003	.96	1.6
Average of five previous years, . .	1.11	6.41	2.58	.0086	.0383	.0322	.0061	.89	.0117	.0002	.94	1.7

Odor in 1902, distinctly vegetable. The organism *Anabæna* was present in large numbers in the sample collected in November.

SALISBURY.

Water examined in Connection with Advice to Wm. Behan. (See also page 36.)

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albu-minoid.		Nitrates.	Nitrites.			
	1902.												
40449	June 10	V. slight.	V. slight.	.21	27.80	.0336	.0120	7.25	.4500	.0002	.28	6.6	.0080
40825	June 30	V. slight.	None.	.17	27.40	.0176	.0146	6.36	.6100	.0001	.02	7.3	.0090

Odor, faintly unpleasant when heated.——The samples were collected from a tubular well at Salisbury Beach.

WATER SUPPLY OF SAUGUS.

(See *Lynn.*)

SCITUATE.

WATER SUPPLY OF SCITUATE. — SCITUATE WATER COMPANY.

Wells.

[Parts per 100,000.]

	Color.	Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
			Free.	Albuminoid.		Nitrates.	Nitrites.			
Average of 13 samples collected in 1902.	.02	15.82	.0007	.0012	3.90	.1835	.0001	.02	4.4	.0089

Waters examined in Connection with Advice to the Scituate Water Company. (See also page 37.)

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		
38874	1902. Feb. 4	None.	V. slight.	1.20	6.10	3.45	.0020	.0188	.0176	.0012	1.01	.0020	.0000	1.40	0.8
38875	Feb. 4	V. slight.	V. slight.	0.98	4.55	2.25	.0020	.0152	.0144	.0008	0.62	.0000	.0000	1.01	0.3
38876	Feb. 4	V. slight.	V. slight.	1.24	6.35	3.35	.0020	.0200	.0196	.0004	1.08	.0050	.0001	1.34	1.0

Odor faintly vegetable, becoming stronger on heating.—— The first sample was collected from Bound Brook near Hackett's shingle mill; the second, from First Herring Brook near Scituate mills; the last, from First Herring Brook near Clapp's mill.

WATER SUPPLY OF SHARON.

Well.

[Parts per 100,000.]

	Color.	Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
					Albuminoid.								
		Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.			
Average of 7 samples collected in 1902.	.01	9.19	–	.0002	.0005	–	–	1.16	.2671	.0000	.02	3.4	.0050
Average of four previous years, .	.01	9.26	–	.0002	.0009	–	–	1.11	.2521	.0000	.02	3.3	.0055

WATER SUPPLY OF SHEFFIELD. — SHEFFIELD WATER COMPANY.

Spring.

[Parts per 100,000.]

	Color.	Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Sus-pended.		Nitrates.	Nitrites.			
Average of 6 samples collected in 1902.	.00	3.43	-	.0005	.0022	-	-	.06	.0072	.0000	.01	1.7	.0047
Average of 6 samples collected in 1901.	.00	3.48	-	.0002	.0007	-	-	.07	.0075	.0000	.02	1.7	.0098

SHIRLEY.

Waters examined in Connection with Advice to the Town Authorities. (See also page 38.)

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albu-minoid.		Nitrates.	Nitrites.			
	1902.												
42132	Sept. 9	None.	None.	.00	3.00	.0000	.0008	0.16	0.0050	.0000	.01	0.6	.0040
42737	Oct. 15	None.	None.	.00	3.30	.0000	.0002	0.15	0.0090	.0000	.02	0.6	.0050
42738	Oct. 15	None.	Slight.	.00	3.00	.0020	.0034	0.21	0.0000	.0002	.04	0.5	.0050

The first two samples were collected from a faucet at the Samson Cordage Works, supplied from a well; the last, from a spring below the Samson Cordage Works.

WATER SUPPLY OF SOMERVILLE.

(See *Metropolitan Water District*, pages 95-99.)

SOUTHBOROUGH.

Waters examined in Connection with Advice to the Town Authorities. (See also page 38.)

	1902.												
40638	June 20	None.	None.	.00	11.20	.0006	.0018	0.93	0.2650	.0000	.01	5.6	.0030
40641	June 20	V. slight.	Slight.	.01	11.70	.0028	.0046	0.85	0.4900	.0050	.01	3.9	.0100
40639	June 20	None.	None.	.00	11.50	.0010	.0028	1.35	0.2000	.0000	.02	5.0	.0030
40640	June 20	None.	V. slight.	.00	23.60	.0576	.0068	1.60	1.5000	.0110	.01	8.9	.0050

Odor of No. 40640, distinctly unpleasant; of No. 40638, faintly unpleasant when heated. —— The first sample was collected from a well on the easterly side of the Marlborough road; the second, from a well located in the village in the rear of the town hall; the third, from a well situated immediately back of the town hall; the last, from a well located in the high school lot about 100 feet from the main street.

SOUTHBRIDGE.

WATER SUPPLY OF SOUTHBRIDGE. — SOUTHBRIDGE WATER SUPPLY COMPANY.

Hatchet Brook Storage Reservoir.

[Parts per 100,000.]

	Color.	Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
					Albuminoid.							
		Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Sus-pended.		Nitrates.	Nitrites.		
Average of 4 samples collected in 1902,	.42	3.00	1.22	.0038	.0188	.0146	.0042	.14	.0017	.0000	.53	0.5
Average of five previous years, . .	.46	3.36	1.55	.0026	.0215	.0174	.0041	.15	.0024	.0000	.57	0.7

Odor in 1902, generally faintly vegetable.

WATER SUPPLY OF SOUTH HADLEY FALLS FIRE DISTRICT.

Leaping Well Reservoir.

Average of 4 samples collected in 1902,	.05	2.74	0.93	.0040	.0162	.0104	.0058	.17	.0015	.0000	.16	0.5
Average of five previous years, . .	.08	2.75	0.93	.0017	.0140	.0101	.0039	.13	.0031	.0000	.13	0.6

Odor in 1902, frequently vegetable or unpleasant.

Buttery Brook Reservoir.

Average of 4 samples collected in 1902,	.21	3.79	1.30	.0074	.0133	.0092	.0041	.25	.0272	.0004	.33	0.9
Average of 4 samples collected in 1901,	.13	3.76	1.29	.0037	.0133	.0093	.0040	.21	.0240	.0002	.17	0.9

Odor in 1902, generally unpleasant.

WATER SUPPLY OF SPENCER.

Shaw Pond.

Average of 4 samples collected in 1902,	.05	2.32	1.04	.0008	.0120	.0107	.0013	.14	.0037	.0000	.14	0.6
Average of five previous years, . .	.05	2.30	0.79	.0017	.0146	.0128	.0018	.16	.0056	.0000	.14	0.6

Odor in March, 1902, faintly unpleasant, becoming stronger on heating.

The organism *Dinobryon* was present in large numbers in the sample collected in March.

WATER SUPPLY OF SPRINGFIELD AND LUDLOW. (See also pages 39, 43.)

Ludlow Reservoir.

Average of 12 samples collected in 1902,	.16	2.62	1.12	.0016	.0217	.0147	.0070	.13	.0042	.0000	.27	0.6
Average of seven previous years, . .	.29	3.15	1.47	.0035	.0356	.0215	.0141	.14	.0035	.0000	.40	0.9

Odor in 1902, faintly vegetable, becoming stronger on heating.

The organism *Anabæna* was present in great numbers in the samples collected during the summer and fall months, and *Uroglena* was present in the samples collected in April and June.

SPRINGFIELD AND LUDLOW.

Jabish Brook Canal, Ludlow.

[Parts per 100,000.]

	Color.	RESIDUE ON EVAPORATION.		AMMONIA.				Chlorine.	NITROGEN AS		Oxygen Consumed.	Hardness.
		Total.	Loss on Ignition.	Free.	ALBUMINOID.				Nitrates.	Nitrites.		
					Total.	Dissolved.	Sus-pended.					
Average of 12 samples collected in 1902,	.39	3.34	1.42	.0020	.0155	.0135	.0020	.14	.0044	.0000	.49	0.9
Average of 45 samples collected in 1901,	.36	3.64	1.43	.0029	.0185	.0147	.0038	.15	.0057	.0001	.48	1.1

Odor in 1902, vegetable, becoming stronger on heating.

Chapin Pond, in Ludlow.

Average of 4 samples collected in 1902,	.06	2.17	1.00	.0014	.0189	.0156	.0033	.09	.0012	.0000	.22	0.4
Average of six previous years, . .	.06	2.37	0.99	.0015	.0199	.0162	.0037	.11	.0022	.0000	.24	0.5

Odor in June, 1902, vegetable; in December, unpleasant.
The organisms *Dinobryon* and *Anabæna* were present in nearly all of the samples examined.

Five Mile Pond.

Average of 4 samples collected in 1902,	.08	2.37	0.97	.0044	.0199	.0178	.0021	.14	.0005	.0000	.24	0.5
Average of six previous years, . .	.09	2.33	1.06	.0054	.0229	.0202	.0027	.14	.0021	.0000	.28	0.4

Odor in 1902, occasionally vegetable.

Loon Pond.

Average of 4 samples collected in 1902,	.03	2.71	1.12	.0020	.0154	.0133	.0021	.21	.0017	.0000	.17	0.8
Average of six previous years, . .	.04	2.50	1.01	.0010	.0190	.0168	.0022	.21	.0027	.0000	.18	0.8

WATER SUPPLY OF STOCKBRIDGE. — STOCKBRIDGE WATER COMPANY.

Lake Averic.

Average of 4 samples collected in 1902,	.07	4.46	1.21	.0020	.0120	.0106	.0014	.05	.0022	.0000	.21	2.6
Average of six previous years, . .	.12	6.28	1.44	.0015	.0176	.0150	.0026	.08	.0033	.0000	.28	4.3

Odor in 1902, generally faintly vegetable or unpleasant.

WATER SUPPLY OF STONEHAM.

(See *Metropolitan Water District*, pages 95–99.)

STOUGHTON.

WATER SUPPLY OF STOUGHTON.

Well.

[Parts per 100,000.]

	Color.	Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Total.	Loss on Ignition.	Free.	Albuminoid.				Nitrates.	Nitrites.			
					Total.	Dissolved.	Suspended.						
Average of 6 samples collected in 1902.	.13	3.60	–	.0007	.0061	–	–	.29	.0047	.0000	.20	0.7	.0145
Average of four previous years, .	.24	3.92	–	.0006	.0089	–	–	.34	.0043	.0000	.32	0.7	.0071

Waters examined in Connection with Advice to the Town Authorities. (See also page 44.)

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
41825	1902. Aug. 22	None.	V. slight.	.00	13.00	.0006	.0084	1.26	.3600	.0010	.26	3.8	.0120
41826	Aug. 22	None.	V. slight.	.00	40.20	.0000	.0064	12.60	.4700	.0005	.18	7.3	.0140

The first sample was collected from a well at the corner of Pearl and Central streets; the last, from a well on the Morton estate in Morton Square.

STURBRIDGE.

Water examined in Connection with Advice to the Fiskdale Mills. (See also page 44.)

36212	1901. June 25	None.	V. slight.	.00	9.50	.0000	.0002	0.15	.0130	.0000	.01	4.7	.0180
36213	June 27	None.	None.	.00	9.70	.0000	.0002	0.15	.0150	.0000	.01	5.0	.0150
36214	June 28	None.	None.	.00	10.00	.0000	.0002	0.17	.0160	.0000	.01	4.9	.0040
36215	July 1	None.	None.	.00	10.00	.0000	.0000	0.16	.0140	.0000	.01	4.7	.0050
36238	July 2	None.	None.	.00	9.80	.0000	.0004	0.16	.0130	.0000	.01	4.9	.0050
36239	July 3	None.	Cons.	.03	10.80	.0006	.0006	0.16	.0130	.0000	.01	4.9	.0090

The samples were collected, during a pumping test, from a group of tubular wells located near the Quinebaug River opposite Mill No. 1 of the Fiskdale Mills.

SUNDERLAND.

Waters examined in Connection with Advice relative to a Proposed Water Supply.
(See also page 45.)

[Parts per 100,000.]

Number.	Date of Collection.	APPEARANCE.			Residue on Evaporation.	AMMONIA.		Chlorine.	NITROGEN AS		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1902.												
39183	Feb. 27	V. slight.	Slight.	.10	4.25	.0000	.0064	.09	.0020	.0000	.19	2.5	–
39184	Feb. 27	Slight.	Slight.	.01	5.40	.0010	.0022	.19	.0430	.0000	.03	3.8	.0160
39186	Feb. 28	V. slight.	Slight.	.05	5.10	.0006	.0038	.11	.0020	.0000	.02	3.6	.0050
39187	Feb. 28	None.	Slight.	.01	5.80	.0004	.0010	.10	.0000	.0000	.03	5.0	.0050

The first sample was collected from Sawmill, or Bear's Den, Brook; the second, from the spring of the Williams Water Company; the third, from the upper spring of the Smith Water Company; the last, from the lower spring of the Smith Water Company.

WATER SUPPLY OF SWAMPSCOTT.

(See *Metropolitan Water District*, pages 95-99.)

WATER SUPPLY OF TAUNTON.

Assawompsett Pond, in Lakeville.

[Parts per 100,000.]

	Color.	RESIDUE ON EVAPORATION.		AMMONIA.				Chlorine.	NITROGEN AS		Oxygen Consumed.	Hardness.	Iron.
					ALBUMINOID.								
		Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.			
Average of 6 samples collected in 1902.	.29	3.39	1.59	.0020	.0177	.0155	.0022	.46	.0013	.0000	.53	0.5	–
Average of eight previous years, .	.33	3.33	1.46	.0009	.0191	.0164	.0027	.51	.0020	.0000	.51	0.6	–

Odor in 1902, vegetable or unpleasant. The organism *Dinobryon* was present in large numbers in the samples collected in January, March and September.

Elder's Pond, in Lakeville.

Average of 6 samples collected in 1902.	.06	3.05	1.24	.0012	.0146	.0123	.0023	.45	.0012	.0000	.28	0.4	–
Average of eight previous years, .	.06	2.60	1.02	.0007	.0161	.0143	.0018	.49	.0020	.0000	.23	0.4	–

Odor in 1902, frequently vegetable or unpleasant. The organism *Dinobryon* was present in the samples collected in January, March and May.

TAUNTON.

Long Pond, in Lakeville.

[Parts per 100,000.]

	Color.	Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Total.	Loss on Ignition.	Free.	Albuminoid.				Nitrates.	Nitrites.			
					Total.	Dissolved.	Suspended.						
Average of 4 samples collected in 1902.	.73	3.61	2.04	.0017	.0184	.0161	.0023	.46	.0010	.0000	.83	0.4	-
Average of nine previous years, .	.87	3.89	2.07	.0006	.0194	.0177	.0017	.49	.0013	.0000	.93	0.4	-

Odor in 1902, faintly vegetable.

TEWKSBURY.

Waters examined in Connection with Advice relative to a Proposed Water Supply. (See also page 46.)

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1902.												
40947	July 2	Decided.	Cons.	.00	19.50	.0016	.0018	1.25	.5200	.0026	.01	6.2	.0400
40948	July 2	Decided.	Cons.	.00	18.80	.0014	.0018	1.25	.5000	.0017	.00	5.7	.0500
40949	July 2	Decided.	Heavy.	-	27.10	.0070	.0072	0.26	.0010	.0001	.25	2.7	.1700
41356	July 25	Decided.	V. slight.	.45	7.40	.0074	.0006	0.22	.0000	.0000	.06	2.3	.1900
41357	July 25	Decided.	Slight.	.47	7.70	.0074	.0004	0.22	.0000	.0000	.03	2.3	.2000
40950	July 2	Decided.	Heavy.	-	10.00	.0074	.0034	0.26	.0010	.0001	.10	3.0	.0900
40951	July 2	Decided.	Cons.	-	8.50	.0038	.0056	0.28	.0000	.0000	.08	2.6	.1100
41358	July 25	Decided.	V. slight.	.60	7.20	.0076	.0002	0.22	.0000	.0000	.03	2.2	.2400
41359	July 25	Decided.	V. slight.	.50	7.40	.0074	.0004	0.22	.0000	.0000	.05	2.3	.2600
40952	July 2	Decided.	Cons.	-	9.70	.0086	.0030	0.28	.0000	.0000	.12	2.5	.1500
41887	Aug. 26	None.	None.	.09	5.30	.0004	.0006	0.31	.0000	.0000	.02	1.4	.0570
41888	Aug. 26	V. slight.	V. slight.	.06	6.30	.0000	.0008	0.38	.0000	.0000	.02	2.0	.0450
42667	Oct. 8	None.	None.	.00	3.50	.0000	.0006	0.37	.0020	.0000	.02	1.6	.0040
42668	Oct. 8	None.	None.	.00	4.50	.0000	.0008	0.37	.0010	.0000	.02	1.8	.0040
42679	Oct. 10	V. slight.	Cons.	.00	6.80	.0004	.0008	0.37	.0020	.0000	.01	1.1	.0050
42680	Oct. 10	None.	V. slight.	.00	3.80	.0002	.0008	0.38	.0010	.0000	.02	1.1	.0040

Odor of No. 40951, unpleasant.—— The samples were collected from tubular test wells located as follows: the first two, in the valley of Strongwater Brook near the first road crossing below the pumping station of the State Hospital; the third, fourth and fifth, in the valley of Strongwater Brook near the first road crossing above the pumping station of the State Hospital; the sixth to the tenth inclusive, in the valley of Strongwater Brook between the Lowell branch of the Boston & Maine Railroad and the first highway crossing above; the last six, in the valley of Heath Brook near its junction with the Shawsheen River.

WATER SUPPLY OF TEWKSBURY STATE HOSPITAL.

Wells.

[Parts per 100,000.]

	Color.	Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
			Free.	Albuminoid.		Nitrates.	Nitrites.			
Average of 5 samples collected in 1902.	.00	3.62	.0006	.0012	0.33	.0318	.0000	.01	1.1	.0062

WATER SUPPLY OF TISBURY. — VINEYARD HAVEN WATER COMPANY.

Spring.

Average of 6 samples collected in 1902.	.01	4.30	.0000	.0004	1.05	.0050	.0000	.01	0.5	.0060
Average of 6 samples collected in 1901.	.00	4.30	.0003	.0016	1.02	.0060	.0000	.02	0.6	.0045

WATER SUPPLY OF WAKEFIELD. — WAKEFIELD WATER COMPANY.

Crystal Lake.

[Parts per 100,000.]

	Color.	Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
					Albuminoid.								
		Total.	Loss on Ignition.	Free	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.			
Average of 4 samples collected in 1902.	.15	4.45	1.75	.0046	.0190	.0155	.0035	.56	.0045	.0001	.35	1.8	-
Average of nine previous years, .	.16	4.48	1.43	.0025	.0179	.0152	.0027	.63	.0110	.0001	.28	1.8	-

Odor in 1902, generally vegetable. The organism *Dinobryon* was present in the samples collected in June and September, and *Uroglena* in the sample collected in December.

WATER SUPPLY OF WALPOLE.

Tubular Wells.

Average of 10 samples collected in 1902.	.00	3.89	-	.0002	.0005	-	-	.32	.0157	.0000	.01	1.1	.0057
Average of six previous years, .	.00	3.68	-	.0001	.0007	-	-	.30	.0079	.0000	.01	1.0	.0048

WATER SUPPLY OF WALTHAM.

Well and Filter Gallery.

Average of 14 samples collected in 1902.	.09	7.28	-	.0043	.0038	-	-	.59	.0243	.0000	.10	3.4	.0257
Average of ten previous years, .	.03	7.02	-	.0030	.0030	-	-	.54	.0235	.0000	.06	3.3	.0096

For the results of examinations of water from the Charles River opposite the well and filter gallery of the Waltham water works, see "Charles River" in the chapter on the "Examination of Rivers."

WARE.

WATER SUPPLY OF WARE.

Well.

[Parts per 100,000.]

	Color.	Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Total.	Loss on Ignition.	Free.	Albuminoid.				Nitrates.	Nitrites.			
					Total.	Dissolved.	Sus-pended.						
Average of 6 samples collected in 1902.	.00	8.42	-	.0000	.0011	-	-	.71	.3550	.0000	.01	3.0	.0047
Average of 7 samples collected in 1901.	.00	7.61	-	.0000	.0009	-	-	.56	.2686	.0000	.01	2.6	.0067

WATER SUPPLY OF ONSET BAY FIRE DISTRICT, WAREHAM. — ONSET WATER COMPANY.

Jonathan's Pond.

Average of 4 samples collected in 1902.	.02	2.37	1.05	.0016	.0113	.0102	.0011	.68	.0017	.0000	.14	0.2	-
Average of 4 samples collected in 1901.	.00	2.49	0.99	.0020	.0137	.0120	.0017	.74	.0022	.0000	.15	0.1	-

The organism *Dinobryon* was present in the samples collected in January and April.

WATER SUPPLY OF WATERTOWN.

(See *Metropolitan Water District*, pages 95-99.)

Water examined in Connection with Advice to Mr. G. W. Lee. (See also page 48.)

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albu-minoid.		Nitrates.	Nitrites.			
39981	1902. May 8	V. slight.	Slight.	.02	11.80	.0014	.0050	.63	.4800	.0006	.04	4.4	.0120

The sample was collected from a well on Hale House Farm, off Bailey Road.

Water Supply of Wayland.

Faucet in Wayland.

[Parts per 100,000.]

	Color.	Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
			Free.	Albuminoid.		Nitrates.	Nitrites.			
Average of 4 samples collected in 1902.	.60	4.94	.0024	.0219	.33	.0640	.0000	.61	1.8	.0297

Odor, generally vegetable or unpleasant.

Water Supply of Webster.

Well.

Average of 6 samples collected in 1902.	.00	3.72	.0002	.0010	.24	.0288	.0000	.01	1.2	.0050
Average of eight previous years, .	.00	3.86	.0002	.0011	.23	.0180	.0000	.01	1.4	.0033

Water Supply of Wellesley.

Filter Gallery.

September, 1902, ...	.00	6.50	.0000	.0026	.40	.0800	.0002	.05	2.0	.0040

Well at Williams Spring.

Average of 2 samples collected in 1902.	.00	10.10	.0003	.0021	.81	.4175	.0001	.02	3.6	.0050
Average of three previous years, .	.01	9.59	.0010	.0014	.78	.4284	.0006	.02	3.5	.0041

Tubular Wells.

Average of 7 samples collected in 1902.	.01	7.50	.0048	.0010	.62	.1587	.0028	.01	3.2	.0100
Average of four previous years, .	.01	7.12	.0018	.0012	.59	.0820	.0017	.02	2.9	.0051

WELLESLEY.

Water examined in Connection with Advice relative to an Additional Water Supply for Wellesley College. (See also page 48.)

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1902.												
41116	July 12	V. slight.	None.	.04	5.80	.0024	.0052	.54	.1500	.0000	.10	3.1	.0050
41384	July 29	V. slight.	V. slight.	.05	6.20	.0026	.0050	.54	.1100	.0000	.15	2.1	.0090

The samples were collected from the end of a tile drain constructed for the purpose of draining the land.

WATER SUPPLY OF WESTBOROUGH.

Lower Sandra Pond.

[Parts per 100,000.]

	Color.	Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Total.	Loss on Ignition.	Free.	Albuminoid.				Nitrates.	Nitrites.			
					Total.	Dissolved.	Suspended.						
Average of 4 samples collected in 1902.	.01	2.69	0.85	.0007	.0064	.0057	.0007	.19	.0017	.0000	.09	1.0	-
Average of six previous years, .	.08	3.09	1.16	.0008	.0122	.0093	.0029	.21	.0027	.0000	.20	1.0	-

The organism *Dinobryon* was present in the sample examined in February.

WATER SUPPLY OF WESTFIELD.

Montgomery Storage Reservoir.

Average of 4 samples collected in 1902.	.56	2.87	1.26	.0056	.0182	.0149	.0033	.10	.0020	.0000	.61	0.3	-
Average of six previous years, .	.54	2.68	1.36	.0026	.0230	.0186	.0044	.11	.0036	.0000	.64	0.4	-

Odor in 1902, vegetable or unpleasant. The organism *Anabæna* was present in the samples collected in August and November.

Tillottson Brook Reservoir, in Granville.

Average of 4 samples collected in 1902.	.09	2.55	0.87	.0009	.0067	.0059	.0008	.11	.0035	.0000	.18	0.4	-
Average of four previous years, .	.10	2.66	0.77	.0006	.0055	.0048	.0007	.12	.0039	.0000	.19	0.5	-

Odor in 1902, generally faintly vegetable or unpleasant when heated.

WATER SUPPLY OF WESTON. — WESTON AQUEDUCT COMPANY.

Well.

[Parts per 100,000.]

		Residue on Evaporation.		Ammonia.					Nitrogen as				
					Albuminoid.								
	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Sus-pended.	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Hardness.	Iron.
Average of 6 samples collected in 1902.	.07	6.28	–	.0003	.0037	–	–	.43	.0603	.0000	.11	2.7	.0080
Average of six previous years, .	.06	6.52	–	.0003	.0039	–	–	.44	.0403	.0000	.09	2.9	.0043

WATER SUPPLY OF WEST SPRINGFIELD.

Darby Brook Storage Reservoir.

Average of 4 samples collected in 1902.	.17	5.20	1.85	.0098	.0214	.0121	.0093	.19	.0057	.0000	.34	2.8	–
Average of five previous years, .	.19	5.26	1.50	.0019	.0171	.0111	.0060	.16	.0049	.0000	.28	2.6	–

Odor in 1902, generally vegetable or unpleasant, becoming stronger on heating.

Receiving Well.

August, 1902, ...	.00	8.00	–	.0008	.0010	–	–	.45	.2160	.0000	.01	2.3	.0060
Average of four previous years, .	.00	7.13	–	.0001	.0016	–	–	.50	.2197	.0000	.03	2.8	.0049

WATER SUPPLY OF WEYMOUTH.

Great Pond.

Average of 4 samples collected in 1902.	.78	3.91	1.67	.0015	.0173	.0158	.0015	.44	.0042	.0000	.76	0.7	–
Average of ten previous years, .	.81	3.96	1.87	.0007	.0190	.0171	.0019	.55	.0033	.0000	.78	0.6	–

Odor in 1902, faintly vegetable, becoming stronger on heating.

WHATELY.

Water examined in Connection with Advice relative to a Proposed Water Supply for Whately and South Deerfield. (See also pages 10, 49.)

[Parts per 100,000.]

		Appearance.			Residue on Evaporation.		Ammonia.					Nitrogen as			
								Albuminoid.							
Number.	Date of Collection.	Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Sus-pended.	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Hardness.
40317	**1902.** June 3	None.	V. slight.	.03	5.30	0.65	.0006	.0034	.0032	.0002	.11	.0090	.0000	.09	3.5

The sample was collected from Roaring Brook in Whately Glen.

WHITMAN.

WATER SUPPLY OF WHITMAN. (See also page 49.)

Hobart's Pond.

[Parts per 100,000.]

		Residue on Evaporation.		Ammonia.					Nitrogen as			
					Albuminoid.							
	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Sus-pended.	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Hardness.
Average of 4 samples collected in 1902,	.47	5.04	1.69	.0053	.0327	.0291	.0036	.92	.0042	.0001	.70	1.6
Average of seven previous years, . .	.65	6.01	2.28	.0025	.0325	.0284	.0041	.83	.0094	.0001	.77	1.7

Odor in 1902, distinctly vegetable, becoming stronger on heating.

Water examined in Connection with Advice to the Town Authorities. (See also page 51.)

[Parts per 100,000.]

		Appearance.				Ammonia.			Nitrogen as				
Number.	Date of Collection.	Turbidity.	Sediment.	Color.	Residue on Evaporation.	Free.	Albu-minoid.	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Hardness.	Iron.
	1901.												
38174	Nov. 29	None.	V. slight.	.00	8.20	.0004	.0036	.86	.2900	.0000	.04	2.5	.0050
	1902.												
38545	Jan. 6	None.	V. slight.	.00	8.30	.0006	.0038	.64	.3200	.0000	.02	4.4	.0130
38565	Jan. 6	V. slight.	V. slight.	.02	8.30	.0002	.0038	.62	.3500	.0000	.02	4.4	.0060

The samples were collected from a well at the Gurney School.

WATER SUPPLY OF WILLIAMSTOWN. — WILLIAMSTOWN WATER COMPANY.

Cold Spring.

[Parts per 100,000.]

		Residue on Evaporation.		Ammonia.					Nitrogen as				
					Albuminoid.								
	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Sus-pended.	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Hardness.	Iron.
Average of 2 samples collected in 1902	.00	15.25	-	.0000	.0003	-	-	.06	.0440	.0000	.01	11.6	.0050
Average of four previous years, .	.01	12.32	-	.0004	.0016	-	-	.06	.0362	.0000	.02	10.7	.0028

Sherman Spring.

[Parts per 100,000.]

	Color.	Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Total.	Loss on Ignition.	Free.	Albuminoid.				Nitrates.	Nitrites.			
					Total.	Dissolved.	Sus-pended.						
Average of 2 samples collected in 1902.	.00	11.40	-	.0000	.0011	-	-	.05	.0200	.0000	.01	8.0	.0055
Average of four previous years, .	.02	8.42	-	.0012	.0061	-	-	.06	.0117	.0000	.04	6.1	.0025

Flora Glen Reservoir.

Average of 2 samples collected in 1902.	.04	5.75	1.37	.0005	.0060	.0039	.0021	.06	.0055	.0000	.10	4.0	-
Average of four previous years, .	.06	5.00	0.82	.0006	.0090	.0064	.0026	.08	.0046	.0000	.10	3.2	-

Paul Brook Reservoir.

Average of 2 samples collected in 1902.	.03	3.62	1.00	.0003	.0031	.0029	.0002	.05	.0090	.0000	.04	2.6	-
Average of four previous years, .	.03	4.47	0.84	.0006	.0091	.0066	.0025	.07	.0104	.0000	.07	3.2	-

WATER SUPPLY OF WINCHENDON.

Well.

Average of 6 samples collected in 1902.	.01	3.15	-	.0020	.0013	-	-	.12	.0040	.0000	.02	0.8	.0115
Average of five previous years, .	.02	3.20	-	.0005	.0014	-	-	.11	.0042	.0000	.03	1.2	.0089

WATER SUPPLY OF WINCHESTER.

North Reservoir.

Average of 4 samples collected in 1902.	.09	4.19	1.50	.0033	.0249	.0182	.0067	.41	.0015	.0000	.26	1.8	-
Average of eleven previous years,	.09	5.59	1.71	.0037	.0229	.0185	.0044	.66	.0107	.0001	.29	2.4	-

Odor in 1902, vegetable or unpleasant, becoming stronger on heating. A large number of organisms was found in all of the samples examined, consisting chiefly of *Diatomaceæ.*

South Reservoir.

Average of 4 samples collected in 1902.	.12	3.40	1.50	.0042	.0218	.0191	.0027	.28	.0055	.0000	.29	1.2	-
Average of eleven previous years,	.23	4.22	1.69	.0057	.0298	.0244	.0054	.36	.0057	.0001	.37	1.7	-

Odor in 1902, vegetable or unpleasant, becoming stronger on heating. The organism *Anabæna* was present in the samples collected in March and June.

WINCHESTER.

Middle Reservoir.

[Parts per 100,000.]

		Residue on Evaporation.		Ammonia.					Nitrogen as				
					Albuminoid.								
	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Hardness.	Iron.
Average of 4 samples collected in 1902.	.20	3.45	1.52	.0193	.0365	.0245	.0120	0.26	.0060	.0004	.38	1.0	-
Average of eight previous years, .	.38	4.21	2.16	.0030	.0531	.0364	.0167	0.35	.0042	.0001	.59	1.2	-

Odor in 1902, unpleasant, becoming stronger on heating. The organism *Anabæna* was present in enormous numbers in the sample collected in June.

WATER SUPPLY OF WINTHROP.

(See *Metropolitan Water District*, pages 95–99.)

WATER SUPPLY OF WOBURN.

Filter Gallery.

Average of 13 samples collected in 1902.	.01	9.82	-	.0062	.0029	-	-	1.15	.0200	.0000	.08	4.6	.0048
Average of eleven previous years,	.01	10.41	-	.0033	.0025	-	-	1.56	.0314	.0000	.05	4.8	.0020

Horn Pond.

Average of 13 samples collected in 1902.	.23	7.73	2.76	.0081	.0267	.0187	.0080	0.88	.0542	.0009	.46	2.9	-
Average of eleven previous years,	.29	8.58	2.29	.0067	.0339	.0213	.0126	1.40	.0504	.0010	.44	3.1	-

Odor in 1902, vegetable and occasionally unpleasant, becoming stronger on heating. The organism *Anabæna* was present in large numbers in the samples collected in July, September and October.

WATER SUPPLY OF WORCESTER. (See also page 51.)

Bottomly Pond, on Kettle Brook, in Paxton.

Average of 6 samples collected in 1902.	.31	2.87	1.47	.0028	.0212	.0174	.0038	0.15	.0057	.0000	.54	0.8	-
Average of seven previous years, .	.42	3.31	1.48	.0052	.0244	.0190	.0054	0.15	.0073	.0001	.57	0.9	-

Odor in 1902, frequently faintly vegetable, becoming stronger on heating. The organism *Anabæna* was present in the sample examined in July.

Kent Reservoir, on Kettle Brook, in Leicester.

Average of 6 samples collected in 1902.	.18	2.93	1.25	.0027	.0167	.0132	.0035	0.15	.0057	.0000	.37	0.7	-
Average of four previous years, .	.31	3.24	1.34	.0030	.0205	.0170	.0035	0.15	.0056	.0001	.47	0.8	-

Odor in 1902, frequently faintly vegetable. The organism *Anabæna* was present in the sample examined in July.

WORCESTER.

Lynde Brook Storage Reservoir.

[Parts per 100,000.]

		Residue on Evaporation.		Ammonia.					Nitrogen as			
					Albuminoid.							
	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Sus-pended.	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Hardness.
Average of 12 samples collected in 1902,	.20	2.82	1.21	.0040	.0135	.0114	.0021	0.16	.0047	.0000	.35	0.7
Average of eleven previous years, .	.29	3.05	1.18	.0041	.0157	.0133	.0024	0.16	.0075	.0000	.39	0.8

Odor in 1902, frequently faintly vegetable or unpleasant. The organism *Uroglena* was present in the samples collected in March and April.

Tatnuck Brook Storage Reservoir.

Average of 12 samples collected in 1902,	.16	2.14	0.88	.0040	.0141	.0103	.0038	0.14	.0026	.0000	.27	0.3
Average of eleven previous years, .	.19	2.25	0.91	.0014	.0155	.0118	.0037	0.14	.0043	.0000	.31	0.4

Odor in 1902, frequently faintly vegetable or unpleasant. The organism *Anabæna* was present in the samples collected in July, August and October, and *Uroglena* in the sample collected in October.

SUMMARY

OF

WATER SUPPLY STATISTICS;

ALSO

RECORDS OF RAINFALL AND FLOW OF STREAMS.

SUMMARY OF WATER SUPPLY STATISTICS.

A water supply was introduced during the year 1902 into the town of Colrain, making the total number of cities and towns in the State provided with public water supplies 168. At the end of the year the State contained 33 cities, all of which were provided with public water supplies, and 320 towns, of which 135 are provided with public water supplies.

The following table gives the classification by population of cities and towns having and not having public water supplies Dec. 31, 1902. The populations are taken from the census of 1900.

POPULATION (1900).	Number of Places of Given Population having a Public Water Supply.	Total Population of Places in Preceding Column.	Number of Places of Given Population not having a Public Water Supply.	Total Population of Places in Preceding Column.
Under 500,	0	0	37	13,383
500 999,	2	1,650	51	39,792
1,000-1,499,	11	13,994	36	43,435
1,500-1,999,	10	17,642	32	54,920
2,000-2,499,	11	24,429	13	29,003
2,500-2,999,	7	18,755	6	16,598
3,000-3,499,	10	32,018	3	10,020
3,500-3,999,	9	33,123	5	18,590
4,000-4,499,	7	29,878	1	4,364
4,500-4,999,	9	42,170	0	0
Above 5,000,	92	2,355,861	1	5,721
Totals,	168	2,569,520	185	235,826

From the totals given in the table it will be seen that 48 per cent. of the total number of cities and towns in the State have a public water supply, and that these places contain 91.6 per cent. of the whole population of the State.

There are now 10 towns, having by the census of 1900 a population exceeding 3,000, which are not provided with public water supplies. These are given in the following table: —

TOWN.	Population in 1900.	TOWN.	Population in 1900.
Blackstone,	5,721	Dartmouth,	3,669
Barnstable,	4,364	Dudley,	3,553
Chelmsford,	3,984	Templeton,	3,489
Pepperell,	3,701	Sutton,	3,328
Tewksbury,	3,683	Hardwick,	3,203

Of the 168 cities and towns having public water supplies, all of the cities and 87 of the towns own their water works, while 48 towns are wholly supplied by private companies.

The following table gives the classification by population of the towns which own their water works and those which are supplied with water by private companies: —

POPULATION (1900).	Number of Places of Given Population owning Water Works.	Total Population of Places in Preceding Column.	Number of Places of Given Population supplied with Water by Private Companies.	Total Population of Places in Preceding Column.
Under 1,000, ...	2	1,650	0	0
1,000-1,999, ...		12,822	12	18,814
2,000-2,999, ...	9	21,600	9	21,584
3,000-3,999, ...	12	41,726	7	23,415
4,000-4,999, ...	13	58,302	3	13,746
5,000-5,999, ...	13	70,870	5	25,923
6,000-6,999, ...	6	38,778	1	6,058
7,000-7,999, ...	7	52,254	4	29,355
8,000-8,999, ...	4	34,212	0	0
9,000-9,999, ...	3	28,786	2	18,763
Above 10,000, ...	42	1,994,520	5	56,342
Totals, ...	120	2,355,520	48	214,000

It will be seen by the totals given in the above table that the population of those towns supplied with water by private companies is only 8 per cent. of the total population in all of the cities and towns supplied with water, and that there are now only 5 towns having a population above 10,000 which are supplied by private companies.

At the beginning of the year 1891 there were 55 cities and towns, having a combined population of 318,319, supplied by private companies. Since that time water has been introduced by private companies into 15 towns, while in 22 cities and towns supplied by private companies the water works have been purchased or taken by the public, making the total number of towns now supplied by private companies 48. The total population of the places supplied by private companies has been reduced during this time from 318,319 to 214,000, a reduction of about one-third.

The following table gives statistics with regard to the consumption of water in cities and towns of this State where such records are kept. The population for 1902 was obtained by adding two-fifths of the increase in population from 1895 to 1900 to the population as determined by the census taken in the latter year. The daily consumption of water per inhabitant has been obtained by dividing the average daily consumption by the estimated population of the city or town in 1902. The quantity obtained in this manner is somewhat less than the average quantity used per consumer, as there are in all cities and towns a greater or less number of people who do not use the public water supply. The difference between the number of inhabitants and the number of consumers is generally much greater in the smaller and sparsely populated than in the larger and more densely populated towns, and in those towns in which a public water supply has been recently introduced than in those which have been supplied with water for a longer period. In some of the towns used as summer resorts, the population during the summer months is much greater than that shown by the census, and in such cases the consumption per inhabitant, as given in the total, is somewhat higher than it would be if allowance were made for the increased population in summer.

Statistics relating to the Consumption of Water in Various Cities and Towns.

City or Town.	Estimated Population in **1902.**	Average Daily Consumption. Gallons. **1902.**	Daily Consumption per Inhabitant. Gallons. **1902.**	City or Town.	Estimated Population in **1902.**	Average Daily Consumption. Gallons. **1902.**	Daily Consumption per Inhabitant. Gallons. **1902.**
Metropolitan Water District.	921,600	110,145,000	120	Framingham, . .	12,018	420,000	35
Abington and Rockland.	9,851	403,000	41	Gardner, . . .	11,465	846,000	74
Amesbury, . .	9,268	403,000	43	Gloucester, . .	25,285	1,045,000	41
Andover, . .	7,080	323,000	46	Grafton, . . .	4,776	96,000	20
Attleborough, .	12,553	433,000	34	Groton, . . .	1,996	67,000	34
Avon, . . .	1,787	62,000	34	Hopkinton, . .	2,479	34,000	14
Ayer, . . .	2,584	92,000	36	Hyde Park, . .	13,811	949,000	69
Beverly, . . .	14,715	1,044,000	71	Ipswich, . . .	4,633	110,000	24
Billerica, . . .	2,854	74,000	26	Lawrence, . .	66,717	3,464,000	52
Braintree, . .	6,249	538,000	86	Longmeadow, .	887	57,000	63
Bridgewater and East Bridgewater.	9,331	187,000	20	Lowell, . . .	99,210	5,729,000	58
Brockton, . .	42,820	1,390,000	33	Lynn and Saugus, .	76,296	4,684,000	62
Brookline, . .	21,443	1,961,000	91	Manchester, . .	2,780	257,000	92
Cambridge, . .	95,983	8,099,000	84	Mansfield, . .	4,120	147,000	36
Canton, . . .	4,563	226,000	50	Marblehead, . .	7,547	484,000	64
Danvers and Middleton.	9,525	702,000	74	Marlborough, . .	13,062	528,000	40
Dedham, . . .	7,555	675,000	89	Maynard, . .	3,163	227,000	72
Easton, . . .	4,991	120,000	24	Methuen, . .	8,240	333,000	40
Fairhaven, . .	3,659	278,000	76	Middleborough, .	6,963	241,000	35
Fall River, . .	111,127	4,365,000	39	Milford and Hopedale.	14,714	791,000	54
Falmouth, . .	3,838	180,000	47	Millbury, . .	4,155	195,000	47
Foxborough, . .	3,285	176,000	54	Montague, . .	6,187	488,000	79

Statistics relating to the Consumption of Water in Various Cities and Towns — Concluded.

CITY OR TOWN.	Estimated Population in 1902.	Average Daily Consumption. Gallons. 1902.	Daily Consumption per Inhabitant. Gallons. 1902.	CITY OR TOWN.	Estimated Population in 1902.	Average Daily Consumption. Gallons. 1902.	Daily Consumption per Inhabitant. Gallons. 1902.
Nantucket, . .	3,002	149,000	50	Salem, . . .	36,549	3,069,000	84
Natick, . . .	9,758	404,000	41	Sharon, . . .	2,197	68,000	31
Needham, . .	4,218	275,000	65	Stoughton, . .	5,510	229,000	42
New Bedford, .	65,318	6,372,000	98	Taunton,. . .	32,604	1,512,000	46
Newburyport, .	14,448	659,000	46	Tisbury, . . .	1,208	64,000	53
Newton, . . .	35,986	1,927,000	54	Wakefield, . .	9,684	577,000	60
North Andover, .	4,513	92,000	20	Walpole, . .	3,803	223,000	59
North Attleborough,	7,523	296,000	39	Waltham, . .	24,523	2,435,000	99
North Brookfield, .	4,568	188,000	41	Ware, . . .	8,508	342,000	40
Norwood, . .	5,842	327,000	56	Wareham, Onset Bay.	3,458	38,000	11
Orange, . . .	5,584	145,000	26	Webster, . .	9,206	341,000	37
Peabody, . .	11,928	1,251,000	107	Wellesley, . .	5,409	257,000	48
Provincetown, .	4,123	143,000	35	Weston, . . .	1,884	48,000	26
Randolph and Holbrook.	6,312	243,000	39	Whitman, . .	6,319	122,000	19
Reading, . . .	5,070	146,000	29	Winchendon, . .	5,205	96,000	18
Rockport, . .	4,314	228,000	53	Woburn, . . .	14,284	1,218,000	85
Rutland, . . .	1,476	60,000	41	Worcester, . .	126,283	8,211,000	65

RAINFALL.

The average yearly rainfall in Massachusetts, as deduced from long-continued observations in various parts of the State, is 45.54 inches. The average rainfall for the year 1902 in those places the records from which were used in obtaining the normal was 45.04 inches, making a deficiency of one-half of an inch. The greatest excess in 1902 occurred in the months of February, March, October and December, and the greatest deficiency occurred in January, May and November. The rainfall in the summer months was not far from the normal.

The following table gives the normal rainfall in the State for each month, as deduced from the observations at various places for a long period of years, together with the average rainfall at those places for each month in 1902, and the departures from the normal: —

MONTH.	Normal Rainfall. Inches.	Rainfall. 1902. Inches.	Excess or Deficiency. 1902. Inches.	MONTH.	Normal Rainfall. Inches.	Rainfall. 1902. Inches.	Excess or Deficiency. 1902. Inches.
January, . .	3.88	2.16	—1.72	August, . .	4.28	3.58	—0.70
February, . .	3.78	5.69	+1.91	September, . .	3.37	4.16	+0.79
March, . . .	4.13	5.73	+1.60	October, . .	4.06	5.10	+1.04
April, . . .	3.48	3.83	+0.35	November, . .	4.09	1.31	—2.78
May, . . .	3.75	1.51	—2.24	December, . .	3.71	5.76	+2.05
June, . . .	3.17	2.76	—0.41				
July, . . .	3.84	3.45	—0.39	Total, . .	45.54	45.04	—0.50

FLOW OF STREAMS.

The flow of streams for the year 1902, as indicated by the records of the Sudbury River, was slightly greater than the normal, although during nine months of the year the flow was less than normal for those months. The months in which an excess occurred were January, March and December. The greatest deficiency occurred in the months of May and November.

In order to show the relation between the flow of the Sudbury River during each month of 1902 and the normal flow of the same river as deduced from observations during the twenty-eight years from 1875 to 1902, inclusive, the following table has been prepared. The area of the watershed of the Sudbury River above the point of measurement is 75.2 square miles.

Table showing the Average Monthly Flow of Sudbury River for the Year 1902 in Cubic Feet per Second per Square Mile of Drainage Area and in Gallons per Day per Square Mile of Drainage Area, also Departures from the Normal Flow.

MONTH.	NORMAL FLOW.		ACTUAL FLOW FOR 1902.		EXCESS OR DEFICIENCY.	
	Cubic Feet per Second per Square Mile.	Gallons per Day per Square Mile.	Cubic Feet per Second per Square Mile.	Gallons per Day per Square Mile.	Cubic Feet per Second per Square Mile.	Gallons per Day per Square Mile.
January, ...	1.894	1,225,000	2.728	1,763,000	+0.834	+538,000
February, ...	2.911	1,881,000	2.590	1,674,000	—0.321	—207,000
March, ...	4.594	2,969,000	6.497	4,199,000	+1.903	+1,230,000
April, ...	3.201	2,068,000	2.916	1,885,000	—0.285	—183,000
May, ...	1.776	1,148,000	1.149	743,000	—0.627	—405,000
June, ...	0.732	473,000	0.469	303,000	—0.263	—170,000
July, ...	0.292	189,000	0.101	66,000	—0.191	—123,000
August, ...	0.456	295,000	0.208	135,000	—0.248	—160,000
September, ...	0.366	236,000	0.276	178,000	—0.090	—58,000
October, ...	0.801	518,000	0.782	506,000	—0.019	—12,000
November, ...	1.404	907,000	0.688	444,000	—0.716	—463,000
December, ...	1.748	1,129,000	2.753	1,779,000	+1.005	+650,000
	1.675	1,083,000	1.746	1,140,000	+0.071	+57,000

The next table shows the weekly fluctuation during 1902 in the flow of three streams which were carefully measured, namely, the Sudbury, the south branch of the Nashua and the Merrimack. The flow of these streams, particularly the Sudbury and the south branch of the Nashua, serves to indicate the flow of the other streams in eastern Massachusetts.

The flow of the Merrimack River is affected to some extent by the diversion of water from two of its tributaries, the Nashua and Sudbury rivers, for the water supply of the metropolitan district. The quantity diverted in 1902 amounted to about 170 cubic feet per second, which would reduce the figures given for the flow per square mile of water-shed about 0.036 cubic feet per second.

The water-shed of the Sudbury River is 75.2 square miles, of the Nashua 119 square miles and of the Merrimack 4,664 square miles.

Week ending Sunday.	Flow in Cubic Feet per Second per Square Mile of Water-shed.			Week ending Sunday.	Flow in Cubic Feet per Second per Square Mile of Water-shed.		
	Sudbury River.	South Branch Nashua River.	Merrimack River.		Sudbury River.	South Branch Nashua River.	Merrimack River.
1902.				**1902.**			
Jan. 5,	7.087	8.201	4.026	July 6,	0.162	0.452	1.111
12,	2.375	2.209	1.596	13,	0.128	0.277	0.871
19,	1.480	1.403	1.189	20,	—0.001	0.397	0.702
26,	4.427	3.342	2.692	27,	0.548	0.517	1.097
Feb. 2,	2.223	2.927	2.165	Aug. 3,	0.275	0.587	0.746
9,	1.788	1.876	1.524	10,	0.204	0.370	0.614
16,	1.113	1.036	1.009	17,	0.195	0.760	1.217
23,	1.022	1.375	0.884	24,	—0.069	0.475	0.741
March 2,	12.028	10.993	3.265	31,	—0.084	0.216	0.747
9,	4.925	4.478	7.750	Sept. 7,	0.116	0.319	0.511
16,	7.473	6.887	5.404	14,	0.500	0.364	0.718
23,	5.706	4.991	5.839	21,	0.220	0.347	0.849
30,	3.882	3.154	4.226	28,	0.160	0.348	0.754
April 6,	2.210	2.829	4.581	Oct. 5,	0.731	0.842	1.519
13,	5.780	6.165	5.291	12,	0.766	1.435	1.420
20,	2.182	2.900	3.365	19,	0.878	1.089	1.120
27,	1.586	1.904	2.341	26,	0.275	0.846	1.091
May 4,	2.706	2.919	3.853	Nov. 2,	1.310	3.024	2.656
11,	1.375	1.769	2.697	9,	0.748	1.248	1.464
18,	0.707	1.138	1.482	16,	0.778	0.819	1.158
25,	0.691	1.012	1.094	23,	0.413	0.641	1.057
June 1,	0.908	1.434	2.146	30,	0.593	0.993	0.937
8,	0.469	0.815	1.205	Dec. 7,	1.360	1.271	1.061
15,	0.488	0.646	0.942	14,	1.050	1.057	0.898
22,	0.397	0.547	1.156	21,	2.701	3.017	1.752
29,	0.051	0.500	1.142	28,	5.886	6.131	3.148

The following table gives the rainfall upon the Sudbury River water-shed and its total yield expressed in inches in depth on the water-shed (inches of rainfall collected) for the year 1902, together with the average of the records of twenty-eight years, from 1875 to 1902 inclusive: —

Rainfall, in Inches, received and collected on Sudbury Water-shed.

MONTH.	1902.			MEAN FOR 28 YEARS, 1875-1902.		
	Rainfall.	Rainfall collected.	Per Cent. collected.	Rainfall.	Rainfall collected.	Per Cent. collected.
January,	2.52	3.145	125.0	4.20	2.184	52.1
February,	6.18	2.697	43.6	4.40	3.055	69.4
March,	5.34	7.491	140.3	4.59	5.296	115.5
April,	4.13	3.254	78.8	3.44	3.571	103.8
May,	1.86	1.325	71.3	3.45	2.048	59.3
June,	2.89	0.523	18.1	2.88	0.817	28.4
July,	2.94	0.117	4.0	3.76	0.337	9.0
August,	3.40	0.240	7.1	4.08	0.526	12.9
September,	4.54	0.308	6.8	3.29	0.408	12.4
October,	4.44	0.902	20.3	4.30	0.924	21.5
November,	1.45	0.767	52.7	4.12	1.566	38.0
December,	6.38	3.173	49.8	3.87	2.015	52.1
Totals and averages,	46.07	23.942	52.0	46.38	22.747	49.0

The Sudbury River records are particularly valuable as a basis for estimating the yield of other water-sheds in Massachusetts, both on account of the accuracy with which the measurements have been made and the absence of abnormal conditions, which would unfavorably affect the results.

The following table gives the records relative to the yield of this water-shed for each of the past twenty-eight years, the flow from the water-shed being expressed in gallons per day per square mile of water-shed, in order to render the table more convenient for use in estimating the probable yield of water-sheds used as sources of water supply.

Yield of the Sudbury River Water-shed in Gallons per Day per Square Mile.[*]

MONTH.	1875.	1876.	1877.	1878.	1879.	1880.	1881.
January,	103,000	643,000	658,000	1,810,000	700,000	1,121,000	415,000
February,	1,496,000	1,368,000	949,000	2,465,000	1,711,000	1,787,000	1,546,000
March,	1,604,000	4,435,000	4,813,000	3,507,000	2,330,000	1,374,000	4,004,000
April,	3,049,000	3,292,000	2,394,000	1,626,000	3,116,000	1,168,000	1,546,000
May,	1,188,000	1,139,000	1,391,000	1,394,000	1,114,000	514,000	965,000
June,	870,000	222,000	597,000	506,000	413,000	176,000	1,338,000
July,	321,000	183,000	202,000	128,000	158,000	177,000	276,000
August,	396,000	405,000	121,000	475,000	395,000	119,000	148,000
September,	207,000	184,000	60,000	160,000	141,000	80,000	197,000
October,	646,000	234,000	632,000	516,000	71,000	101,000	186,000
November,	1,302,000	1,088,000	1,418,000	1,693,000	206,000	205,000	395,000
December,	584,000	454,000	1,289,000	3,177,000	462,000	175,000	775,000
Av. for whole year,	972,000	1,135,000	1,214,000	1,452,000	894,000	578,000	979,000
Av. for driest six months,	574,000	384,000	502,000	532,000	230,000	143,000	330,000

MONTH.	1882.	1883.	1884.	1885.	1886.	1887.	1888.
January,	1,241,000	335,000	995,000	1,235,000	1,461,000	2,589,000	1,053,000
February,	2,403,000	1,033,000	2,842,000	1,354,000	4,800,000	2,829,000	1,951,000
March,	2,839,000	1,611,000	3,785,000	1,572,000	2,059,000	2,868,000	3,237,000
April,	867,000	1,350,000	2,853,000	1,815,000	1,947,000	2,620,000	2,645,000
May,	1,292,000	938,000	1,030,000	1,336,000	720,000	1,009,000	1,632,000
June,	529,000	300,000	417,000	426,000	203,000	414,000	422,000
July,	86,000	115,000	224,000	62,000	115,000	114,000	117,000
August,	55,000	78,000	257,000	240,000	94,000	214,000	380,000
September,	306,000	91,000	44,000	121,000	118,000	111,000	1,155,000
October,	299,000	186,000	83,000	336,000	146,000	190,000	1,999,000
November,	210,000	205,000	175,000	1,178,000	673,000	368,000	2,758,000
December,	314,000	193,000	925,000	1,174,000	1,020,000	643,000	3,043,000
Av. for whole year,	862,000	533,000	1,129,000	901,000	1,087,000	1,154,000	1,697,000
Av. for driest six months,	211,000	145,000	200,000	391,000	223,000	234,000	953,000

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[*] The area of the Sudbury River water-shed used in making up these records included water surfaces amounting to about 2 per cent. of the whole area, from 1875 to 1878 inclusive, subsequently increasing by the construction of storage reservoirs to about 3 per cent. in 1879, to 3.5 per cent. in 1885, to 4 per cent. in 1894 and to 6.5 per cent. in 1898. The water-shed also contains extensive areas of swampy land, which, though covered with water at times, are not included in the above percentages of water surfaces.

Yield of the Sudbury River Water-shed in Gallons per Day per Square Mile — Concluded.

MONTH.	1889.	1890.	1891.	1892.	1893.	1894.	1895.
January, ...	2,782,000	1,254,000	3,018,000	1,870,000	433,000	693,000	1,034,000
February, ...	1,195,000	1,529,000	3,486,000	943,000	1,542,000	991,000	541,000
March, ...	1,339,000	3,643,000	4,453,000	1,955,000	3,245,000	2,238,000	2,410,000
April, ...	1,410,000	1,875,000	2,397,000	871,000	2,125,000	1,640,000	2,515,000
May, ...	880,000	1,366,000	582,000	1,259,000	2,883,000	840,000	636,000
June, ...	653,000	568,000	414,000	428,000	440,000	419,000	174,000
July, ...	633,000	108,000	149,000	214,000	158,000	161,000	231,000
August, ...	1,432,000	132,000	163,000	280,000	181,000	209,000	229,000
September, ...	824,000	458,000	203,000	229,000	108,000	150,000	89,000
October, ...	1,230,000	2,272,000	210,000	126,000	221,000	374,000	1,379,000
November, ...	1,941,000	1,215,000	305,000	697,000	319,000	836,000	2,777,000
December, ...	2,241,000	997,000	544,000	485,000	797,000	716,000	1,782,000
Av. for whole year, . .	1,383,000	1,285,000	1,315,000	781,000	1,037,000	770,000	1,152,000
Av. for driest six months, .	944,000	747,000	239,000	327,000	237,000	356,000	460,000

MONTH.	1896.	1897.	1898.	1899.	1900.	1901.	1902.	Mean for 28 Years, **1875** to **1902**, inclusive.
January, ...	1,084,000	845,000	1,638,000	2,288,000	794,000	437,000	1,763,000	1,225,000
February, ...	2,676,000	1,067,000	3,022,000	1,381,000	3,800,000	300,000	1,674,000	1,881,000
March, ...	3,835,000	2,565,000	2,604,000	4,205,000	3,654,000	2,755,000	4,199,000	2,969,000
April, ...	1,494,000	1,515,000	1,829,000	2,521,000	1,350,000	4,204,000	1,885,000	2,068,000
May, ...	360,000	915,000	1,246,000	511,000	1,312,000	2,954,000	743,000	1,148,000
June, ...	399,000	962,000	530,000	66,000	316,000	753,000	303,000	473,000
July, ...	95,000	658,000	231,000	19,000	—18,000	306,000	66,000	189,000
August, ...	57,000	591,000	1,107,000	—35,000	—34,000	424,000	135,000	295,000
September, ...	388,000	182,000	369,000	94,000	65,000	305,000	178,000	236,000
October, ...	592,000	94,000	1,160,000	115,000	186,000	412,000	506,000	518,000
November, ...	659,000	909,000	1,986,000	304,000	663,000	474,000	444,000	907,000
December, ...	657,000	1,584,000	1,799,000	220,000	1,096,000	2,695,000	1,779,000	1,129,000
Av. for whole year, . .	1,019,000	991,000	1,450,000	973,000	1,082,000	1,342,000	1,140,000	1,083,000
Av. for driest six months, .	314,000	564,000	777,000	93,000	194,000	445,000	271,000	435,000

EXPERIMENTS

UPON THE

PURIFICATION OF SEWAGE AND WATER

AT THE

LAWRENCE EXPERIMENT STATION,

DURING THE YEAR 1902.

Experiments upon the Purification of Sewage and Water at the Lawrence Experiment Station.*

By H. W. Clark, *Chemist of the Board.*

The following report presents a summary of investigations upon the purification of sewage and water at the Lawrence Experiment Station during the year 1902.

Analyses of Sewage.

The following table gives the average analyses of the various samples of sewage collected during the year; "Lawrence Street sewage" being the average of samples collected weekly from the sewer from which the sewage is pumped to the experiment station, "regular station sewage" being the average of samples collected at the experiment station on at least four days each week, "sewage applied to Filters Nos. 1, 6 and 9A" being the average of samples collected from all sewage applied to these filters, and "average sewage" being the average of all sewage pumped upon each Tuesday of the year. These averages are as follows: —

[Parts per 100,000.]

	Ammonia.			Chlorine.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
	Free.	Albuminoid.				
		Total.	In Solution.			
Lawrence Street sewage, ...	2.62	.88	.55	13.54	7.70	2,478,000
Regular Station sewage, ...	4.49	.72	.31	10.11	4.06	3,377,400
Sewage applied to Filters Nos. 1, 6 and 9A,	4.26	.71	–	10.70	4.53	–
Average sewage, ...	4.80	.87	.34	10.49	4.80	2,765,300

The average temperature of the regular station sewage when applied to the filters varied from 42° F. in January to 68° F. in July and August. The sewage flowing in the Lawrence Street sewer varied in temperature from 50° F. in January and February to 70° F. in August.

Solids in Sewage.

The solid matter in suspension is the chief factor in the clogging of the surface of sand filters. The area of sand filter needed to purify a given volume of sewage depends very largely upon the amount of matters in suspension. The determination of these solids, therefore, is of special value in comparing one sewage with another.

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* The work has been carried on under the general supervision of Hiram F. Mills, A. M., C. E., member of the State Board of Health, with the writer in direct charge. A full account of the work done at the Lawrence Experiment Station for the years 1888 and 1889 is contained in a special report of the State Board of Health upon the purification of sewage and water, 1890. A similar account for the years 1890 and 1891 is contained in the twenty-third annual report of the Board for 1891. Since 1891 the results have been published yearly in the annual reports.

During the first two years of the operation of the station daily determinations were made of the amount of solid matters in the sewage and the amount of combustible matter; that is, determinations of the total solids and the loss on ignition. These determinations were omitted during the period from November, 1889, to July, 1902, but were then resumed in connection with studies of the septic tank and contact filters.

The following table shows the average solid matters present in the station sewage (1) from December, 1887, to October, 1889, inclusive, and (2) from July 1 to Dec. 31, 1902, inclusive: —

Average Solids in Station Sewage from December, 1887, to October, 1889, inclusive.

[Parts per 100,000.]

UNFILTERED.			FILTERED.			IN SUSPENSION.		
Total.	Loss on Ignition.	Fixed.	Total.	Loss on Ignition.	Fixed.	Total.	Loss on Ignition.	Fixed.
56.52	24.33	32.19	33.41	10.70	22.71	23.11	13.63	9.48

Average Solids in Station Sewage from July 1 to Dec. 31, 1902, inclusive.

73.20	34.20	39.00	52.40	18.30	34.10	20.80	15.90	4.90

TREATMENT OF SEWAGE TO REMOVE MATTERS IN SUSPENSION.

During the year the regular sewage as pumped to the station has been treated in various ways, to remove, destroy or put into solution the matters in suspension in it before application to the filters. The principal experiments along this line have been the continuation of septic tanks and coal strainers.

Septic Sewage.

Septic Tank A, having a capacity of about 220 gallons, was put into operation in November, 1897, and was continued throughout the year 1902. The tank is divided into three sections, and was at first air-tight; later, petcocks and pipes were attached above for the ready escape of the large volume of gas generated. The tank has been operated without removal of sludge, and at the end of 1902 about 30 per cent. of its capacity was filled with this matter. The two following tables show the average analyses of the sewage entering and the effluent from this tank during 1902. It will be seen by these averages that, of the total organic matter of the sewage entering the tank during the year, as shown by the albuminoid ammonia determinations, 40 per cent. did not appear in the effluent of the tank; also, that 20 per cent. of the organic matter in solution in the sewage, as shown by the albuminoid ammonia determinations, did not appear in its effluent, and 57 per cent. of the organic matter in suspension. The oxygen consumed determinations show that 32 per cent. of the organic matter determined in this way was removed from the sewage or destroyed by passage through the tank.

Sewage as it enters Septic Tank A.

[Parts per 100,000.]

1902.	Temperature (Deg. F.).	AMMONIA.			Chlorine.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Free.	ALBUMINOID.				
			Total.	In Solution.			
January,	39	5.50	0.86	.44	7.45	4.45	300,000
February,	38	6.70	1.01	.62	12.64	5.61	4,090,000
March,	44	4.47	0.67	.38	15.41	4.00	1,773,000
April,	48	5.68	0.70	.37	10.14	3.82	1,670,000
May,	55	4.38	0.63	.31	11.92	4.03	2,210,000
June,	64	4.38	0.66	.26	13.49	3.80	4,102,500
July,	68	4.30	0.51	.22	17.77	3.60	1,330,000
August,	67	4.70	1.06	.28	11.29	5.20	2,710,000
September,	68	4.67	0.70	.33	13.96	3.79	1,360,000
October,	63	4.03	0.45	.24	9.47	3.24	2,380,000
November,	52	4.08	0.68	.34	9.02	4.58	3,170,000
December,	40	3.60	0.58	.32	8.56	4.38	1,976,000
Average,	54	4.71	0.71	.34	11.76	4.21	2,256,000

Effluent of Septic Tank A.

1902.	Temperature (Deg. F.).	AMMONIA.			Chlorine.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Free.	ALBUMINOID.				
			Total.	In Solution.			
January,	44	4.68	0.52	.39	8.22	3.38	176,500
February,	43	4.28	0.50	.32	9.06	3.70	773,000
March,	49	4.35	0.40	.27	11.53	2.82	393,000
April,	50	4.98	0.38	.26	10.33	2.37	316,500
May,	54	5.08	0.39	.25	11.08	2.69	2,456,000
June,	64	4.90	0.37	.23	11.80	2.25	809,000
July,	67	4.60	0.41	.22	13.87	2.33	546,000
August,	65	5.60	0.44	.24	15.35	2.76	1,350,000
September,	66	4.77	0.43	.23	14.82	2.48	821,000
October,	64	3.50	0.37	.22	11.20	2.85	1,346,500
November,	52	4.28	0.50	.30	10.80	3.42	1,532,000
December,	44	3.16	0.39	.26	6.94	3.14	1,721,000
Average,	55	4.52	0.43	.27	11.25	2.85	1,020,000

Average Solids in Sewage entering and Effluent from Septic Tank A.

The following table gives the results of determinations of the actual amount of solid matter found in the sewage entering the tank and in its effluent during the last six months of 1902, together with the percentage removal by passage through the tank: —

Average Solids in Sewage entering Septic Tank A.

[Parts per 100,000.]

1902.	UNFILTERED.			FILTERED.			IN SUSPENSION.		
	Total.	Loss on Ignition.	Fixed.	Total.	Loss on Ignition.	Fixed.	Total.	Loss on Ignition.	Fixed.
June, . . .	79.4	37.9	41.5	53.0	18.4	34.6	26.4	19.5	6.9
July, . . .	81.8	33.6	48.2	70.3	26.1	44.2	11.5	7.5	4.0
August, . . .	97.8	53.2	44.6	56.8	20.0	36.8	41.0	33.2	7.8
September, . .	74.3	35.0	39.3	56.9	21.7	35.2	17.4	13.3	4.1
October, . . .	65.0	30.9	34.1	46.8	15.7	31.1	18.2	15.2	3.0
November, . .	74.7	40.6	34.1	46.9	18.9	28.0	27.8	21.7	6.1
December, . .	65.5	32.4	33.1	45.5	18.8	26.7	20.0	13.6	6.4
Average, . .	76.9	37.7	39.2	53.7	19.9	33.8	23.2	17.8	5.4
Average Solids in Septic Sewage A.									
June, . . .	54.2	19.6	34.6	48.2	14.3	33.9	6.0	5.3	0.7
July, . . .	62.9	25.8	37.1	41.4	14.9	26.5	21.5	10.9	10.6
August, . . .	67.6	24.6	43.0	58.0	15.4	42.6	9.6	9.2	0.4
September, . .	61.9	23.4	38.5	54.7	17.2	37.5	7.2	6.2	1.0
October, . . .	58.3	23.5	34.8	46.6	15.1	31.5	11.7	8.4	3.3
November, . .	61.7	28.3	33.4	52.1	19.7	32.4	9.6	8.6	1.0
December, . .	51.1	25.4	25.7	41.7	18.9	22.8	9.4	6.5	2.9
Average, . .	59.7	24.4	35.3	49.0	16.5	32.5	10.7	7.9	2.8
Percentage removal,	22.4	35.3	-	8.8	17.1	-	53.9	55.6	-

Andover Septic Tank.

The experimental septic tank of the Board at the sewage works of the town of Andover was kept in operation until July, 1902, having been started during the summer of 1899. This tank has a capacity of 9,000 gallons. Exceedingly strong and very old sewage was passed through it, and, while fairly successful as a sludge destroyer, the sewage was rendered, like that of Septic Tank B, mentioned in previous reports, difficult to purify by intermittent or contact filtration without preliminary aeration. During its period of operation it removed or destroyed about 55 per cent. of the nitrogenous organic matter of the entering sewage, as shown by albuminoid ammonia determinations. The period of passage of the sewage averaged about fourteen hours. At the end of two years and six months the deposit on the bottom of the tank occupied 11 per cent. of the tank capacity. It is the intention to operate this tank again if conditions at this area change.

The following tables show the average analyses of the sewage entering and the effluent from this tank during 1902: —

Andover Sewage.

[Parts per 100,000.]

1902.	Temperature (Deg. F.).	AMMONIA.			Chlorine.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Free.	ALBUMINOID.				
			Total.	In Solution.			
January,	42	5.88	1.31	.72	5.63	6.08	1,710,000
February,	41	9.10	1.86	.78	6.04	10.05	6,455,000
March,	39	4.40	1.22	.65	6.32	5.36	1,690,000
April,	46	6.80	1.47	.68	5.98	7.20	4,685,000
May,	54	8.30	1.36	.78	6.99	6.55	4,305,000
June,	57	10.30	2.31	.84	67.83	10.77	3,680,000
Average,	47	7.46	1.59	.74	16.47	7.67	3,754,000

Effluent from Experimental Septic Tank in Andover, Mass.

January,	43	5.00	0.69	.51	7.16	3.80	763,000
February,	41	8.10	0.90	.64	7.95	5.47	1,220,000
March,	41	3.60	0.50	.34	4.48	3.00	159,000
April,	46	4.80	0.51	.33	5.79	2.78	990,000
May,	51	6.70	0.82	.45	9.39	4.22	748,800
June,	57	8.90	0.76	.46	13.72	4.99	746,500
Average,	47	6.18	0.70	.46	8.08	4.04	771,200

Straining Sewage through Coal.

Strainers of anthracite coal — buckwheat size* — have been in operation since 1899, and have been more successful than the strainers of coke, owing to the greater weight of the material, which tends to keep it in a compact mass, and prevents a mixture of the coal and the matters in suspension in the sewage.

Coal Strainer E was put into operation Feb. 1, 1901, and contained 1 foot in depth of buckwheat coal over gravel underdrains. Its rate of operation until June 22, 1902, was 1,000,000 gallons per acre daily, and from that date until the end of the year 1,400,000 gallons per acre daily. During this period of twenty-three months it was scraped but seven times, a large amount of sludge being removed each time. So little coal was removed with the sludge that its depth was decreased but about 4 inches. The removal of organic matter at this higher rate was 44 per cent. of the total organic matter, and 64 per cent. of the suspended matter, as shown by the albuminoid ammonia determinations.

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* All would pass through a screen with a ½-inch mesh, and practically none through a screen with an ⅛-inch mesh.

The following tables show the average analyses of the sewage applied to and the effluent from this strainer during 1902: —

Sewage applied to Strainer E.

[Parts per 100,000.]

1902.	Temperature (Deg. F.).	Ammonia.			Chlorine.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Free.	Albuminoid.				
			Total.	In Solution.			
January,	38	4.45	0.65	.33	7.44	3.42	1,410,000
February,	44	4.10	0.57	.32	6.39	3.26	1,850,000
March,	43	4.30	0.54	.31	7.67	2.88	1,670,000
April,	47	3.43	0.49	.23	10.63	3.12	1,143,000
May,	59	6.13	0.69	.38	9.52	3.84	1,800,000
June,	65	6.23	1.10	.41	9.88	5.73	2,193,000
July,	69	5.55	1.05	.39	10.76	3.86	2,440,000
August,	-	5.30	0.30	.18	10.60	2.20	-
September,	66	6.90	0.78	.43	11.13	4.04	1,630,000
October,	52	5.63	0.67	.33	8.67	3.83	90,630,000
November,	48	4.93	0.75	.37	11.43	4.24	2,395,000
December,	43	4.19	0.62	.33	6.88	3.36	2,285,000
Average,	52	5.10	0.68	.33	9.25	3.65	9,950,000

Effluent of Strainer E.

January,	52	4.85	0.36	.26	7.50	2.41	281,000
February,	51	5.05	0.40	.31	6.63	2.32	514,700
March,	56	5.60	0.25	.21	6.98	1.50	530,300
April,	54	4.20	0.23	.20	9.46	1.65	301,700
May,	59	7.07	0.31	.23	9.20	1.56	248,300
June,	67	5.83	0.40	.22	9.93	2.25	663,300
July,	68	6.50	0.45	.36	10.07	2.48	844,500
August,	66	5.50	0.24	.19	10.55	1.42	-
September,	64	4.95	0.34	.23	8.24	1.76	985,000
October,	54	4.30	0.43	.20	7.98	2.48	1,074,700
November,	55	5.48	0.45	.28	8.64	3.19	935,000
December,	51	4.40	0.44	.27	6.79	2.42	838,700
Average,	58	5.31	0.36	.25	8.50	2.12	656,100

Comparative Removal of Mineral and Organic Matter by a Septic Tank and Coal Strainers.

The following table presents some interesting figures in regard to the removal from sewage by Septic Tank A, Coal Strainer E and a still shallower coal strainer, of the total solids, mineral matter and combustible or organic matter. These figures represent the results of many determinations of solids between June 1 and Dec. 31, 1902. It will be noticed that Coal Strainer E was the most efficient during the period presented.

Percentages of Solid Matter, Combustible Matter and Mineral Matter removed from sewage by Septic Tank A, Strainer E and a Shallow Coal Strainer, June 1, to Dec. 31, 1902.

	Septic Tank A.	Strainer E.	Shallow Coal Strainer.
Solids.			
Total,	22.4	28.7	11.60
In solution,	8.8	9.5	0.56
In suspension,	53.8	77.1	42.40
Combustible Matter. (Loss on Ignition.)			
Total,	35.3	42.9	18.60
In solution,	17.1	8.5	4.00
In suspension,	55.6	82.2	45.00
Mineral Matter. (Fixed Solids.)			
Total,	9.9	16.4	6.20
In solution,	3.8	10.0	2.80
In suspension,	66.7	59.2	33.30

PURIFICATION OF SEPTIC SEWAGE.

Filtration of Septic Sewage A.

Two of the filters, which have received Septic Sewage A since the installation of a septic tank five years ago, were continued in operation during 1902. Filter No. 100 is constructed of 5 feet in depth of sand of an effective size of 0.23 millimeter, and Filter No. 103 is a coke contact filter 5 feet in depth, the coke in this filter being of such size that all will pass through a sieve with a ½-inch mesh, and practically none through a sieve with an ⅛-inch mesh. The sand filter has been operated at a rate somewhat greater than during 1901, and has given a somewhat better effluent. The contact filter has been operated at a rate considerably greater than during 1901, and the effluent has been of a somewhat poorer quality than during the previous year. The following tables give the average analyses of the effluents of these two filters for the year: —

Effluent of Filter No. 100.

[Parts per 100,000.]

1902.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature. Deg. F.		Length of Time Sewage Remained on Surface. — Hours and Minutes.	Appearance.		Ammonia.			Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
								Albuminoid.						
		Sewage.	Effluent.		Turbidity.	Color.	Free.	Total.	In Solution.		Nitrates.	Nitrites.		
Jan., .	485,200	44	44	–	V. slight.	.30	0.0860	.0535	–	8.14	2.73	.0007	0.43	10,400
Feb., .	283,300	43	48	–	Slight.	.46	0.0914	.1080	–	8.94	3.18	.0227	0.77	147,600
Mar , .	307,700	49	49	–	Slight.	.52	0.0227	.0819	–	9.14	2.22	.0007	0.44	76,200
Apr., .	319,200	50	48	–	Slight.	.29	0.6067	.0547	–	9.57	1.78	.0090	0.47	48,000
May, .	266,700	54	56	2h. 27m.	Decided.	–	5.4500	.1820	–	10.42	0.03	.0000	1.90	49,400
June, .	300,000	64	63	32m.	Slight.	.24	0.5377	.0600	.0540	11.82	4.81	.0038	0.44	102,700
July, .	300,000	67	69	38m.	Slight.	.28	0.4550	.0540	–	12.86	2.81	.0043	0.51	44,600
Aug , .	288,500	65	65	34m.	Slight.	.22	0.1850	.0420	–	13.35	4.20	.0002	0.40	34,100
Sept., .	230,800	66	63	43m.	Slight.	.36	0.4333	.0620	–	12.45	4.36	.0031	0.56	15,300
Oct., .	210,400	64	56	18m.	Decided.	.43	0.7020	.1033	.0600	11.47	2.51	.0029	0.91	99,300
Nov., .	300,000	52	58	21m.	Decided.	.31	0.4700	.0900	.0645	8.65	3.59	.0038	0.73	72,000
Dec., .	288,900	44	55	23m.	Slight.	.39	0.4004	.0768	.0620	8.89	2.78	.0044	0.72	42,000
Av.,	298,400	55	56	45m.	–	.35	0.7867	.0807	.0600*	10.48	2.92	.0046	0.69	69,300

* Average for four months.

Effluent of Filter No. 103.

[Parts per 100,000.]

1902.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature. Deg. F.		Turbidity.	Color.	Ammonia.			Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
							Albuminoid.						
		Sewage.	Effluent.			Free.	Total.	In Solution.		Nitrates.	Nitrites.		
January, .	1,021,900	44	46	Great.	.39	1.7200	.2140	.1170	9.06	1.64	.0060	1.33	337,400
February, .	1,011,700	48	47	Great.	.62	1.8333	.2320	.1280	9.86	0.53	.0024	1.58	191,000
March, . .	775,800	49	50	Great.	.60	1.7200	.1840	.0850	10.32	0.53	.0045	1.29	81,400
April, . .	804,600	50	49	Decided.	.40	1.0600	.1480	.0660	9.07	2.56	.0070	0.84	304,900
May, . .	658,700	54	53	Decided.	.36	1.6400	.1240	.0680	11.93	0.91	.0050	0.95	316,700
June, . .	641,200	64	64	Decided.	.48	1.5400	.1293	.0760	12.83	1.04	.0120	0.95	243,400
July, . .	752,600	67	70	Decided.	.43	1.2200	.0980	.0880	13.49	0.79	.0113	0.77	100
August, .	768,500	65	64	Decided.	.37	1.0400	.1120	.0740	13.62	1.84	.0140	0.71	173,500
September, .	830,800	66	63	Slight.	.50	1.7667	.1413	.1040	12.96	1.18	.0133	1.01	176,300
October, .	844,400	64	56	Decided.	.48	1.3217	.1233	.0827	11.17	1.57	.0173	1.03	300,300
November, .	707,600	52	58	Decided.	.41	0.8733	.1320	.1047	9.46	0.56	.0110	1.05	284,500
December, .	825,000	44	53	Decided.	.64	1.0900	.1380	.1045	10.05	0.66	.0082	1.06	243,500
Average,	803,600	56	56	–	.47	1.4021	.1480	.0915	11.15	1.15	.0093	1.05	221,000

Mineral and Organic Matter in Effluent of Contact Filter No. 103.

The following table presents the amount of mineral and organic matter in the effluent of contact Filter No. 103. The small amount of solid matter in suspension is noticeable. The amount of solids in this effluent is to be compared with the amount in the effluent of Septic Tank A (see page 182), as this sewage has always been applied to the filter. The reduction in organic matter as shown by the loss on ignition results is very noticeable, being about 60 per cent. in the unfiltered and 50 per cent. in the filtered sample.

Average Solids in Effluent of Filter No. 103.

[Parts per 100,000.]

1902.	Unfiltered.			Filtered.			In Suspension.		
	Total.	Loss on Ignition.	Fixed.	Total.	Loss on Ignition.	Fixed.	Total.	Loss on Ignition.	Fixed.
June, . . .	50.2	11.3	38.9	43.9	9.9	34.0	6.3	1.4	4.9
July, . . .	47.8	10.1	37.7	47.3	9.9	37.4	0.5	0.2	0.3
August, . . .	54.2	8.2	46.0	52.8	6.4	46.4	1.4	1.8	-
September, . .	48.3	9.1	39.2	46.6	7.8	38.8	1.7	1.3	0.4
October, . .	47.6	10.8	36.8	44.2	9.7	34.5	3.4	1.1	2.3
November, . .	40.7	10.1	30.6	39.9	9.7	30.2	0.8	0.4	0.4
December, . .	40.7	9.1	31.6	39.2	7.9	31.3	1.5	1.2	0.3
Average, . .	47.1	9.8	37.3	44.8	8.7	36.1	2.3	1.1	1.2

Filtration of Andover Septic Sewage.

The three filters in operation at Andover during 1900 and 1901 were continued until the end of June, 1902. They were as follows: an intermittent sand filter, $\frac{1}{200}$ of an acre in area, containing 5 feet in depth of sand of an effective size of 0.23 millimeter; a coke contact filter, $\frac{1}{200}$ of an acre in area, containing 5 feet in depth of coarse coke; and a small coke contact filter, containing 4 feet in depth of comparatively fine coke. The sand filter was operated at a rate of 105,000 gallons per acre daily, and at this rate a very poor effluent was produced. The large coke filter was operated at the rate of 380,000 gallons per acre per day, and, although some organic matter was removed from the applied sewage by passage through this filter, little nitrification occurred, and the effluent was of a very poor quality. The effluent of this filter was applied to the small contact filter at a rate of 352,000 gallons per acre daily, and a considerable improvement in its quality resulted, nitrification being fairly active during the period of operation. This septic tank and the filters were discontinued at the end of June, as it had been quite conclusively proved that, with the old and somewhat stale sewage reaching the Andover area, septic tank action was not favorable to subsequent purification. The following tables give the average analyses of the effluents of these filters during their period of operation in 1902: —

Effluent of the Experimental Sand Filter at Andover, Mass.

[Parts per 100,000]

1902.	Temperature. Deg. F.		Turbidity.	Color.	Ammonia.			Chlorine.	Nitrogen as		Oxygen Consumed	Bacteria per Cubic Centimeter.
						Albuminoid.						
	Sewage.	Effluent.			Free.	Total.	In Solution.		Nitrates.	Nitrites.		
January, .	43	34	V. slight.	0.96	4.9500	.2380	.2160	6.15	0.02	.0013	1.73	56,400
February, .	41	36	Slight.	1.22	5.9200	.2700	.2100	7.35	0.02	.0000	1.94	25,800
March, . .	41	42	V. slight.	0.39	3.8400	.1400	–	4.99	2.80	.0160	0.55	34,400
April, . .	46	48	V. slight.	0.29	1.6750	.0780	–	6.52	3.27	.0045	0.40	7,850
May, . .	51	55	Slight.	0.52	1.7700	.1760	.1510	11.08	1.68	.0210	1.05	38,600
June, . .	57	64	Slight.	1.17	4.0600	.3233	.2600	16.11	1.41	.0150	2.05	178,900
Average,	47	47	–	0.76	3.7025	.2042	.2093	8.70	1.53	.0096	1.29	56,992

Effluent of the Large Experimental Coke Contact Filter at Andover, Mass.

[Parts per 100,000.]

1902.	Temperature. Deg. F.		Turbidity.	Color.	Ammonia.			Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
						Albuminoid.						
	Sewage.	Effluent.			Free.	Total.	In Solution.		Nitrates.	Nitrites.		
January, .	42	40	V. slight.	.77	3.1900	.2780	.2310	5.34	.15	.0095	1.67	260,500
February, .	41	36	Decided.	.76	5.8500	.5350	.4480	7.95	.03	.0000	3.24	391,000
March, . .	39	42	V. slight.	.30	0.9400	.0920	–	2.08	.22	.0240	0.40	175,500
April, . .	46	48	V. slight.	.31	1.8200	.1720	.1310	3.48	.25	.0100	0.82	437,000
May, . .	54	53	Decided.	.88	4.0200	.3370	.2200	6.63	.01	.0000	2.07	613,000
June, . .	57	61	Decided.	black.	6.2250	.5300	.4133	8.86	.02	.0000	2.93	854,000
Average,	47	47	–	.60	3.6742	.3240	.2887	5.72	.11	.0073	1.86	455,200

Effluent of the Small Experimental Coke Contact Filter at Andover, Mass.

[Parts per 100,000.]

1902.	Temperature. Deg. F.		Turbidity.	Color.	Ammonia.			Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
						Albuminoid.						
	Sewage.	Effluent.			Free.	Total.	In Solution.		Nitrates.	Nitrites.		
January, .	40	32	V. slight.	.39	1.4800	.1820	.1240	5.42	1.18	.0775	1.20	113,500
February, .	38	33	Decided.	.73	3.6500	.4240	.3220	6.90	0.68	.1925	2.69	694,500
March, . .	42	34	V. slight.	.40	0.0670	.0990	–	2.48	0.98	.0280	0.34	399,000
April, . .	48	49	V. slight.	.25	0.1230	.0820	.0480	3.49	1.46	.0180	0.41	140,000
May, . .	53	60	Slight.	.38	1.5400	.1940	.0660	7.45	1.00	.0144	0.99	63,700
June, . .	61	65	Slight.	.80	3.2600	.2560	.1320	9.67	1.15	.1170	1.28	381,000
Average,	47	46	–	.49	1.6867	.2062	.1384	5.90	1.08	.0746	1.15	298,600

CONTACT FILTRATION.

Treatment of Sewage in a Contact Filter of Broken Stone, — Filter No. 137, $\frac{1}{20000}$ of an Acre in Area.

In February, 1900, Filter No. 137 was put into operation. It was constructed of broken stone, of such a grade that all the pieces would pass through a sieve with a 1-inch mesh, and practically none through a sieve with a ½-inch mesh. It was operated during the year at a rate of 480,000 gallons per acre daily, and was filled in three applications of sewage two hours apart. It was continued in operation during 1901 and 1902 at higher rates, as shown in the following table. The best results were obtained during 1900, when the rate of operation was lowest, and the filter was comparatively free from clogging. Its effluent, however, has never approached in quality the effluents of contact filters of rough and porous materials.

The following table shows the average analyses of its effluent during the past year: —

Effluent of Filter No. 137.

[Parts per 100,000.]

1902.	Quantity Applied. Gallons per Acre Daily for Six Days in a Week.	Temperature. Deg. F.		Turbidity.	Color.	Ammonia.			Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Sewage.	Effluent.			Free.	Albuminoid. Total.	Albuminoid. In Solution.		Nitrates.	Nitrites.		
January, . .	816,500	52	48	Great.	0.48	2.0500	.2500	.1690	7.54	.02	.0012	1.87	124,500
February, .	742,900	52	49	Great.	0.77	3.9333	.3027	.1687	9.93	.02	.0000	2.11	330,200
March, .	860,000*	47	-	-	-	-	-	-	-	-	-	-	-
April, .	841,500	51	50	Great.	0.79	3.4300	.2620	.1940	8.79	.02	.0016	1.78	477,700
May, . .	816,900	58	58	Great.	0.68	2.7900	.2470	.1340	10.16	.01	.0009	1.78	459,400
June, . .	815,000	65	63	Great.	0.77	2.9667	.8167	.1573	9.80	.57	.0213	3.93	1,216,300
July, . .	815,000	68	70	Great.	1.27	2.9000	.6150	.1520	14.35	.42	.0730	3.76	1,629,000
August, .	783,700	69	-	Slight.	0.52	3.5000	.3600	.2000	11.80	.41	.0060	2.24	-
September,	626,900	65	63	Decided.	0.82	2.9350	.4280	.1460	11.08	.81	.0320	2.87	1,795,000
October, .	667,800	55	53	Decided.	1.33	2.6250	.3900	.1720	8.11	.21	.0055	2.99	896,500
November,	596,000	49	56	Decided.	0.95	4.2500	.4800	.2510	13.64	.14	.0055	2.85	508,300
December,	751,100	50	51	Decided.	1.05	2.8750	.4450	.2360	10.14	.15	.0050	3.44	399,000
Average,	761,100	57	56	-	0.85	3.1132	.4179	.1800	10.49	.25	.0138	2.65	783,800

* Six days.

Double Contact Filtration, — Filter No. 163.

The effluent of Filter No. 137, $\frac{1}{20000}$ of an acre in area, has been applied to a filter of rather fine coke — No. 163, $\frac{1}{20000}$ of an acre in area — at an average rate of 706,000 gallons per acre daily. Nitrification has been good, and a fairly well-purified effluent obtained.

Effluent of Filter No. 163.

[Parts per 100,000.]

1902.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature. Deg. F.		Turbidity.	Color.	Ammonia.			Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
							Albuminoid.						
		Sewage.	Effluent.			Free.	Total.	In Solution.		Nitrates.	Nitrites.		
January, .	841,500	48	48	Great.	.58	0.4800	.1340	.0990	7.86	1.70	.0032	1.11	344,000
February, .	670,400	49	48	Decided.	.51	0.9933	.1680	.1013	9.40	2.47	.0108	1.15	1,532,000
March, .	700,000*	-	-	-	-	-	-	-	-	-	-	-	-
April, .	636,200	50	52	Decided.	.41	1.0125	.1425	.0875	9.07	1.37	.0081	0.89	236,500
May, . .	607,800	58	58	Slight.	.46	1.0463	.1150	.0725	9.27	1.52	.0165	0.77	97,200
June, . .	596,800	63	64	Decided.	.73	1.2667	.1607	.0993	10.22	3.15	.0193	0.82	563,200
Average,	675,450	54	54	-	.54	0.9598	.1440	.0919	9.16	2.04	.0116	0.95	554,600

* Four days.

Treatment of Sewage in a Contact Filter constructed of Limonite, — Filter No. 165.

Filter No. 165, $\frac{1}{20000}$ of an acre in area, in operation for eleven months during 1901 and six months during 1902, contained 5 feet in depth of limonite over 3 inches in depth of gravel underdrains. It received four doses of regular sewage, one hour apart, stood full two hours, and was then slowly drained. The object of this experiment was to determine whether this natural iron oxide would exert any oxidizing influence on the organic matter which adhered to it. At an average rate of about 600,000 gallons per acre daily the results did not differ materially from those obtained from other contact filters of a similar grade of material. During the last months of its operation poor results were obtained, as the material was really too fine for use in contact filtration, and became clogged with mineral and organic matter.

The action of iron in intermittent and contact filters has been discussed in previous reports.

Effluent of Filter No. 165.

[Parts per 100,000.]

1902.	Quantity Applied.	Temperature. Deg. F.		Turbidity.	Color.	Ammonia.			Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
	Gallons per Acre Daily for Six Days in a Week.	Sewage.	Effluent.			Free.	Albuminoid.			Nitrates.	Nitrites.		
							Total.	In Solution.					
January, .	1,087,400	52	50	Decided.	.60	2.4400	.2180	.1530	6.80	.65	.0060	1.34	441,700
February, .	950,000	52	50	Decided.	.68	4.2000	.2347	.1493	11.64	.01	.0009	1.35	293,200
March, .	302,500	47	49	Decided.	.48	0.8000	.1480	.0980	8.09	.23	.0016	0.88	14,900
April, .	361,200	51	51	Decided.	.42	1.3267	.1347	.0853	8.82	.20	.0017	0.76	180,600
May, . .	217,400	58	57	Decided.	.42	1.2000	.1420	.0770	8.75	.01	.0009	0.91	78,800
June, . .	500,000	65	63	Decided.	.63	1.0350	.1640	.1040	10.05	.01	.0032	1.02	313,800
Average,	569,750	54	53	–	.54	1.8336	.1736	.1111	9.03	.19	.0024	1.04	220,500

Comparison of the Purification of Untreated Sewage and of Strained Sewage in Contact Filters of Coke.

Filters Nos. 175 and 176 were started on June 3, 1901, and they are still in operation. They are constructed of 5 feet in depth of coke, of such a size that all will pass through a screen with a 1-inch mesh, 75 per cent. through a screen with a ½-inch mesh, and practically none through a screen with a ¼-inch mesh. Each is $\frac{1}{20000}$ of an acre in area. The effluent of Coal Strainer F is applied to Filter No. 175, and Filter No. 176 has received regular station sewage. Until Oct. 1, 1901, the filters were flooded with four applications of sewage one hour apart, allowed to stand full for two hours, and then drained slowly. From October 1 to November 7 each was flooded in four applications of sewage one hour apart, and allowed to stand full two hours before being drained. Beginning November 7, each filter was filled in one application of sewage, about forty-five minutes being taken to fill each filter to its surface. The changes in the manner of flooding made comparatively little difference in the degree of purification obtained from each filter, although the best results have been obtained when flooding in successive doses. Filter No. 175, receiving strained sewage, has always given the better effluent, and has been operated at the higher rate.

Effluent of Filter No. 175.

[Parts per 100,000.]

1902.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature. Deg. F.		Turbidity.	Color.	Ammonia.			Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Sewage.	Effluent.			Free.	Albuminoid. Total.	Albuminoid. In Solution.		Nitrates.	Nitrites.		
January, .	1,600,000	42	52	Great.	0.48	2.2900	.2090	.1450	9.26	0.54	.0023	1.33	369,000
February, .	1,520,800	44	52	Great	0.61	1.8433	.2280	.1140	9.40	1.27	.0015	1.55	500,000
March, .	501,300	46	53	Decided.	0.48	1.4000	.1640	.0660	9.41	1.14	.0008	1.12	292,000
April, .	697,100	49	55	Decided.	0.39	1.5867	.1480	.0907	9.07	1.51	.0016	0.88	207,300
May, . .	708,900	61	62	Decided.	0.58	1.6550	.2040	.1130	14.53	1.87	.0030	1.22	127,500
June, .	492,000	68	68	Decided.	0.49	1.1600	.1680	.1280	13.13	2.31	.0028	1.04	559,000
July, . .	640,200	67	64	Great.	1.00	2.4800	.2840	.1640	10.66	1.76	.0020	1.52	-
August, .	734,200	70	68	Decided.	0.45	1.0500	.1660	.1100	10.29	1.76	.0030	1.16	465,000
September,	536,200	63	64	Decided.	0.64	1.0000	.1680	.1000	12.92	2.12	.0016	1.19	557,000
October, .	592,600	53	55	Decided.	0.54	0.9600	.1220	.0830	9.70	2.27	.0035	0.98	189,000
November,	567,200	50	63	Decided.	0.48	0.6700	.1660	.1030	12.27	2.54	.0033	1.06	1,093,000
December,	627,400	43	59	-	0.52	0.3950	.1160	.0810	7.31	1.74	.0075	0.87	324,000
Average,	768,200	55	60	-	0.56	1.3742	.1786	.1081	10.66	1.74	.0027	1.16	425,700

Effluent of Filter No. 176.

January, .	1,440,000	52	46	Slight.	0.35	1.5650	.1390	.0950	8.00	0.82	.0023	0.78	286,500
February, .	1,375,800	52	46	Decided.	0.48	2.4000	.2093	.1040	9.38	0.25	.0008	1.23	263,800
March, .	493,100	47	48	Decided.	0.43	0.4000	.1520	.1180	7.74	0.92	.0024	0.94	345,000
April, .	622,300	51	49	Decided.	0.33	1.0467	.1613	.1047	8.30	0.69	.0024	0.97	232,000
May, . .	601,500	58	59	Decided.	1.28	2.6500	.2320	.1180	11.07	0.12	.0018	1.69	116,500
June, .	508,000	65	67	Decided.	0.38	1.7000	.1980	.0860	9.84	0.14	.0007	1.20	547,000
July, . .	540,400	68	66	Slight.	0.50	2.8800	.2520	.1060	10.23	0.03	.0016	1.32	-
August, .	622,300	69	67	Decided.	0.43	0.4300	.1400	.0840	10.90	1.13	.0025	1.06	295,000
September,	387,800	65	63	Decided.	0.61	1.5400	.1880	.1320	10.83	1.30	.0044	1.23	650,500
October, .	639,600	55	54	Decided.	0.83	0.8500	.1810	.1360	8.50	1.50	.0045	1.46	478,000
November,	540,200	49	59	Decided.	0.58	1.4600	.2460	.1640	11.91	0.30	.0020	1.55	1,158,000
December,	613,300	50	56	Decided.	0.55	0.5100	.1290	.0900	6.58	0.75	.0028	0.94	353,000
Average,	698,700	57	57	-	0.56	1.4526	.1856	.1115	9.44	0.66	.0024	1.20	429,600

The following table shows the average solid matter — mineral and organic — in the sewage applied to the coal strainer and to Filter No. 176, and in the effluent of the coal strainer as applied to Filter No. 175, together with the solids in the effluent of these two filters. This coal strainer, owing to its shallowness, was not particularly efficient during the year. Studying the results, it will be seen that the effluent of Filter No. 176 contained only about 40 per cent. as much combustible matter as the sewage applied, and about 67 per cent. as much total solid matter. The effluent of Filter No. 175, receiving strained sewage, contained as much combustible organic matter as did the effluent of Filter No. 176. Complete analyses, however, showed the effluent of Filter No. 175 to be the purer of the two.

Average Solids in Sewage applied to Coal Strainer F.

[Parts per 100,000.]

1902.	UNFILTERED.			FILTERED.			IN SUSPENSION.		
	Total.	Loss on Ignition.	Fixed.	Total.	Loss on Ignition.	Fixed.	Total.	Loss on Ignition.	Fixed.
June,	78.5	31.5	47.0	61.0	15.6	45.4	17.5	15.9	1.6
July,	67.7	30.9	36.8	53.9	19.3	34.6	13.8	11.6	2.2
August,	60.4	28.0	32.4	51.2	19.2	32.0	9.2	8.8	0.4
September,	79.8	32.0	47.8	53.8	15.8	38.0	26.0	16.2	9.8
October,	62.0	26.5	35.5	46.0	15.7	30.3	16.0	10.8	5.2
November,	88.9	44.1	44.8	59.0	17.7	41.3	29.9	26.4	3.5
December,	67.2	32.3	34.9	46.9	17.8	29.1	20.3	14.5	5.8
Average,	72.1	32.2	39.9	53.0	17.3	35.7	19.0	14.9	4.1

Average Solids in Effluent of Coal Strainer F, applied to Filter No. 175.

June,	66.3	22.9	43.4	59.0	15.7	43.3	7.3	7.2	0.1
July,	64.3	26.7	37.6	54.0	18.4	35.6	10.3	8.3	2.0
August,	59.6	23.6	36.0	48.2	16.2	32.0	11.4	7.4	4.0
September,	66.7	28.0	38.7	57.5	23.3	34.2	9.2	4.7	4.5
October,	56.1	24.5	31.6	46.5	17.8	28.7	9.6	6.7	2.9
November,	77.2	33.5	43.7	57.3	18.3	39.0	19.9	15.2	4.7
December,	55.5	24.5	31.0	46.1	16.0	30.1	9.4	8.5	0.9
Average,	63.7	26.2	37.4	52.7	18.0	34.7	11.0	8.3	2.7

Average Solids in Effluent of Filter No. 175.

June,	59.5	12.7	46.8	58.8	11.0	47.8	0.7	1.7	–
July,	52.4	15.6	36.8	51.1	15.1	36.0	1.3	0.5	0.8
August,	46.5	13.5	33.0	45.1	12.7	32.4	1.4	0.8	0.6
September,	55.9	14.5	41.4	54.3	12.8	41.5	1.6	1.7	–
October,	54.4	11.5	42.9	53.0	11.0	42.0	1.4	0.5	0.9
November,	58.0	13.6	44.4	55.8	12.8	43.0	2.2	0.8	1.4
December,	44.2	11.8	32.4	41.3	9.9	31.4	2.9	1.9	1.0
Average,	53.0	13.3	39.7	51.3	12.2	39.2	1.6	1.1	0.9

Average Solids in Effluent of Filter No. 176.

June,	51.4	12.7	38.7	42.2	7.8	34.4	9.2	4.9	4.3
July,	46.5	10.0	36.5	42.2	8.0	34.2	4.3	2.0	2.3
August,	49.5	14.0	35.5	47.0	13.0	34.0	2.5	1.0	1.5
September,	50.9	10.8	40.1	47.9	8.7	39.2	3.0	2.1	0.9
October,	49.5	17.0	32.5	47.9	15.8	32.1	1.6	1.2	0.4
November,	48.7	13.5	35.2	46.0	12.5	33.5	2.7	1.0	1.7
December,	42.3	12.1	30.2	38.6	8.9	29.7	3.7	3.2	0.5
Average,	48.4	12.9	35.5	44.5	10.7	33.8	3.9	2.2	1.7

Efficiency of Different Materials in Contact Filtration.

Of all the materials employed in the construction of filters of this class at the Lawrence Experiment Station, by far the best results have been given by coke. Rough materials give better qualitative results than smooth materials. Broken stone filters have not been particularly efficient, nitrification has seldom been active within them, and the matters separated from the sewage and retained within such filters do not remain evenly distributed throughout the filter, but accumulate in the lower layers. A non-putrescible effluent from a contact filter of broken stone is not easily obtained, unless the stone is of so fine a grade that the filter will clog rapidly. With the use of rough materials, such as coke, the disappearance of the nitrogen of the free ammonia of the applied sewage is very marked; that is, a large percentage of this nitrogen does not appear either as free ammonia in the effluent, or as nitrates or nitrites, and presumably passes away uncombined. The cause of this loss will be discussed later. The average purification obtained by contact filters, calculated in decrease of albuminoid ammonia, is seldom above 75 per cent.

Permanency of Contact Filters.

Next to giving good purification, the length of life or the permanency of a sewage filter is the most important consideration. In the operation of sand filters receiving fresh sewage, where practically all the matters in suspension in the applied sewage are retained at or near the surface, this deposit can, if necessary, be removed from time to time without much disturbance of the main body of the filter. With a contact filter of coarse material, however, upon which practically no surface straining takes place, the lower portions are as liable to clogging as the upper. This clogging or filling of the open spaces decreases the volume of the sewage that can be applied daily, and limits the life of the filter. To maintain normal rates and at the same time produce good qualitative results, the experience at the station and elsewhere shows the importance of removing a considerable portion of the matters in suspension before the sewage is applied to these filters, if the filters are to be constructed of material fine enough to produce good results. This removal may be accomplished by sedimentation, straining, septic tanks, etc.

The following data upon the rapidity of the filling of the open space of filters receiving various grades of sewage have been obtained from the operation of various contact filters, and are presented in the following tables.

Filters Nos. 82, composed of cinders; 137, of broken stone; 176, of coke; and 165, of limonite, — received untreated sewage for the periods given in the tables, and their open space was reduced as shown. Filter No. 176 is still in operation. Filter No. 137 was without underdrains, and the clogging was largely in its lower layers. Each of these filters with exception of No. 82 was $\frac{1}{20000}$ of an acre in area. Filter No. 82 was $\frac{1}{10000}$ of an acre in area.

Decrease of Open Space.

Filter No. 82, constructed of Cinders.

COMMENCED TO OPERATE.	Date when Open Space was determined.	Period of Operation.	Per Cent. of Open Space.	Per Cent. Reduction of Open Space.	
April 12, 1897, . . .	- -	- -	60.00*	-	
	Sept 14, 1899.	2 yrs. 4 m.	-	-	
	June 15, 1900.	2 yrs. 9 m.	53.00	11.7	
	Dec. 18, 1900.	3 yrs. 3 m.	50.00	16.7	
	Jan. 29, 1901.	3 yrs. 4 m.	47.00	21.7	
	Mar. 1, 1901.	3 yrs. 6 m.	45.00	25.0	

Filter No. 137, constructed of Broken Stone.

Feb. 21, 1900, . . .	- -	- -	45.00*	-	
	May 4, 1900.	2.5 m.	42.00	6.7	
	Jan. 30, 1901.	11 m.	33.00	26.7	
	May 25, 1901.	1 yr. 3 m.	27.00	40.0	
	July 1, 1901.	1 yr. 4 m.	24.00	46.7	
	Jan. 3, 1902.	1 yr. 10 m.	15.50	65.6	
	Feb. 3, 1902.	1 yr. 11 m.	13.00	71.1	Tank emptied February 28.

Filter No. 165, constructed of Limonite.

Feb. 3, 1901, . . .	- -	- -	35.00	-	
	July 5, 1901.	5 m.	30.50	12.9	
	Jan. 3, 1902.	11 m.	27.00	22.9	
	Feb. 3, 1902.	1 yr.	24.00	31.4	
	Feb. 27, 1902.	1 yr. 1 m.	19.35	44.7	
	Mar. 10, 1902.	1 yr. 1.5 m.	22.00	37.1	
	Apr. 3, 1902.	1 yr. 2 m.	18.50	47.1	
	May 3, 1902.	1 yr. 3 m.	18.25	47.9	
	June 9, 1902.	1 yr. 4 m.	25.00	28.6	
	July 1, 1902.	1 yr. 5 m.	21.00	40.0	

* Approximate.

Filter No. 176, Constructed of Medium Coarse Coke.

BEGAN TO OPERATE.	Date when Open Space was determined.	Period of Operation.	Per Cent. of Open Space.	Per Cent. Reduction.	
June 3, 1901, .	- -	- -	48.00	-	
	June 18, 1901.	½ m.	42.75	10.9	
	Sept. 28, 1901.	3 m.	40.00	16.7	
	Oct. 10, 1901.	4 m.	42.00	12.5	
	Oct. 11, 1901.	4 m.	39.00	18.8	
	Oct. 14, 1901.	4 m.	39.50	17.7	
	Dec. 2, 1901.	6 m.	39.50	17.7	
	Dec. 4, 1901.	6 m.	37.50	21.9	
	Dec. 31, 1901.	7 m.	36.00	25.0	
	Feb. 4, 1902.	8 m.	34.25	28.6	
	Mar. 1, 1902.	9 m.	29.00	39.6	Rested Mar. 2 to 9.
	Mar. 10, 1902.	9.5 m.	34.00	29.2	
	April 2, 1902.	10 m.	31.00	35.4	
	May 3, 1902.	11 m.	31.25	34.9	Rested June 6 to 12.
	June 13, 1902.	1 yr.	34.00	29.2	
	July 3, 1902.	1 yr. 1 m.	31.50	34.4	Rested July 28 to Aug 3.
	Sept. 15, 1902.	1 yr. 3.5 m.	36.00	25.0	Rested Sept. 8 to 14.
	Oct. 7, 1902.	1 yr. 4 m.	39.25	18.2	Rested Sept 24 to Oct. 6.
	Nov. 3, 1902.	1 yr. 5 m.	35.00	27.1	Rested Nov. 17 to 23.
	Nov. 24, 1902.	1 yr. 6 m.	35.00	27.1	Rested Dec. 29 to Jan. 4, 1903.

Filter No. 103, started more than five years ago, is still in operation, and has received during its entire period of operation septic sewage. It is allowed to rest every six weeks. Its rate of operation at present is approximately 1,400,000 gallons per acre daily, and its open space is only 16 per cent. less than when started. At the present time, while this open space fluctuates, it is not permanently decreasing. The increased open space after each period of rest is noticeable.

Filter No. 175 receives sewage which has first been passed through a coke strainer, and for the past year its percentage of open space has remained practically constant.

Decrease of Open Space.

Filter No. 103, constructed of Fine Coke.

BEGAN TO OPERATE.	Date when Open Space was determined.	Period of Operation.	Per Cent. of Open Space.	Per Cent. Reduction.	
Feb. 28, 1898,	- -	- -	30.00	-	
	Jan. 29, 1901.	2 yrs. 11 m.	27.00	10.0	
	July 1, 1901.	3 yrs. 4 m.	26.00	13.3	
	Nov. 1, 1901.	3 yrs. 8 m.	25.50	15.0	
	Nov. 6, 1901.	- -	25.00	16.7	Material flushed November 11.
	Nov. 12, 1901.	- -	26.00	13.3	Tank emptied and material put in new tank November 14.
	Nov. 15, 1901.	- -	29.00	3.3	
	Nov. 29, 1901.	3 yrs. 9 m.	25.75	14.2	
	Jan. 7, 1902.	3 yrs. 11 m.	25.50	15.0	
	Feb. 4, 1902.	4 yrs.	25.50	15.0	
	Feb. 27, 1902.	4 yrs. 1 m.	23.00	23.3	Rested March 2 to 9.
	Mar. 10, 1902.	4 yrs. 1.5 m.	27.50	8.3	
	Apr. 3, 1902.	4 yrs. 2.5 m.	21.00	30.0	Rested April 5 to 13.
	Apr. 14, 1902.	4 yrs. 3 m.	27.00	10.0	
	May 3, 1902.	4 yrs. 3.5 m.	22.25	25.8	Rested May 16 to 25.
	May 26, 1902.	4 yrs. 4 m.	28.00	6.7	
	June 9, 1902.	4 yrs. 4.5 m.	24.50	18.3	
	July 3, 1902.	4 yrs. 5.5 m.	21.00	30.0	Rested July 13 to 20.
	July 21, 1902.	4 yrs. 6 m.	27.00	10.0	Rested August 25 to 31.
	Oct. 10, 1902.	4 yrs. 9 m.	30.00	0.0	Rested September 24 to October 9.
	Nov. 4, 1902.	4 yrs. 10 m.	21.25	29.2	Rested November 16 to 23.
	Nov. 24, 1902.	4 yrs. 11 m.	24.75	17.5	Rested December 29 to Jan. 3, 1903.
	Jan. 5, 1903.	5 yrs.	25.00	16.7	

Filter No. 175, Constructed of Medium Coarse Coke.

June 3, 1901, .	- -	- -	48.00	-	
	June 18, 1901.	0.5 m.	45.00	6.3	
	Oct. 1, 1901.	4 m.	42.00	12.5	
	Dec. 2, 1901.	6 m.	43.50	9.4	
	Dec. 4, 1901.	6 m.	42.00	12.5	
	Dec. 31, 1901.	7 m.	40.00	16.7	
	Feb. 4, 1902.	8 m.	37.75	21.4	
	Mar. 1, 1902.	9 m.	35.50	26.0	Rested March 2 to 10.
	Mar. 11, 1902.	9.5 m.	36.25	24.5	
	Apr. 2, 1902.	10 m.	36.25	24.5	
	May 3, 1902.	11 m.	36.75	23.4	Rested June 6 to 12.
	June 13, 1902.	1 yr.	41.00	14.6	
	July 3, 1902.	1 yr. 1 m.	37.25	22.4	Rested July 28 to August 5.
	Sept. 15, 1902.	1 yr. 3.5 m.	41.00	14.6	Rested September 8 to 14.
	Oct. 9, 1902.	1 yr. 4 m.	40.00	16.7	Rested September 24 to October 8.
	Nov. 3, 1902.	1 yr. 5 m.	36.50	24.0	Rested November 17 to 23.
	Nov. 24, 1902.	1 yr. 6 m.	38.50	19.8	Rested December 27 to Jan. 4, 1903.

Many other contact filters have given like results; that is, it has been shown that the permanency or maintenance of open space is dependent upon preliminary treatment of the sewage applied, and frequent resting of the filter. Good underdrainage is a very essential feature, especially in filters of smooth materials, as in these filters there is a constant tendency to sedimentation of the matters retained in the filters, which, with open underdrains, pass away instead of remaining to clog the lower layers.

PURIFICATION WITHOUT NITRIFICATION.

Statements have been made during the past year, by various investigators, in regard to the purification or at least the satisfactory treatment of sewage by contact filters *without* nitrification occurring in the filters. If the production of clarified effluents containing organic matter of such a nature that it changes but slowly after coming from the filter is meant by this assertion, certain Lawrence results present frequent illustrations. The effluents of intermittent sand filters Nos. 1, 6 and 9A, during periods of the past two winters, have been clear, practically odorless and non-putrefactive, notwithstanding they did not contain nitrates. Certain contact filters, constructed of or containing large amounts of metallic iron, have also produced effluents containing but a small percentage of the organic matter of the sewage applied to them, and have been practically non-putrefactive, notwithstanding that nitrification did not occur in these filters. These have been special cases, however, and the results are not of general application. It can be stated emphatically that it has not been the general experience at Lawrence that good purification can be obtained without nitrification.

INTERMITTENT CONTINUOUS FILTRATION.

Filters Nos. 135 and 136, $\frac{1}{20000}$ of an Acre in Area.

Filters Nos. 135 and 136, when first started in 1899, were 18 feet in depth. All of the broken stone used in their construction will pass through a screen with a 1-inch mesh, 40 per cent. through a screen with a ½-inch mesh, and 4 per cent. through a screen with a ¼-inch mesh. The sewage has been distributed over the surface of the filters by means of trays and automatic tipping basins, that flush the sewage first over one portion of the surface and then over the other, discharging their contents every few minutes. On June 20, 1900, 6 feet of filtering material was removed from each filter, making the depth of each 11 feet 10 inches.

These filters were continued in operation throughout 1902, and were both operated in the intermittent continuous manner. Each contained during this period 11 feet 10 inches in depth of the filtering material. Filter No. 135 has received the effluent of Coal Strainer E, and Filter No. 136 has received septic sewage. At the beginning of the year 1901 nitrification became feeble in both filters, owing to the conditions prevailing, caused by their great depth as compared with their surface area; that is to say, nitrogen and carbonic acid gas accumulated within them, and the difficulty with which these gases could escape and air enter prevented bacterial oxidation. To remedy this, on May 27, 1901, four openings were made on the side of each filter, about 4½ feet from the top of the filtering material. Following this, nitrification began to be active in both filters, and has so continued up to the present time (April, 1903). The average rate of filtration of Filter No. 135 for 1901 was 1,407,000 gallons per acre daily, and of Filter No. 136 1,403,000 gallons per acre daily. The average rate during 1902 of Filter No. 135 was 1,817,400 gallons per acre daily, and of Filter No. 136, 1,809,100 gallons per acre daily. During each of these years Filter No. 135 has received sewage that has first passed through a coal strainer, and Filter No. 136 has received septic sewage.

The following tables give the average yearly analyses for 1900 and 1901 of the sewage applied to and the effluents from these filters, and the average monthly analyses of sewage and effluents during 1902: —

Average Analyses of Sewage applied to Filter No. 135.

[Parts per 100,000.]

YEAR.	Temperature. Deg. F.	AMMONIA.				Chlorine.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Free.	ALBUMINOID.					
			Total.	In Solution.	In Suspension.			
1900, . .	60	4.09	.62	.27	.35	9.02	4.31	1,449,400
1901, . .	61	6.41	.35	.29	.06	9.70	2.08	383,300

Average Analyses of Sewage applied to Filter No. 136.

1900, . .	62	4.67	.33	.22	.11	9.74	2.45	648,800
1901, . .	60	5.98	.39	.29	.10	8.73	2.58	352,000

Effluent of Filter No. 135.

YEAR.	Quantity Applied. Gallons per Acre Daily.	Color.	AMMONIA.			Chlorine.	NITROGEN AS		Oxygen Consumed.	Bacteria per Cubic Centimeter.
			Free.	ALBUMINOID.			Nitrates.	Nitrites.		
				Total.	In Solution.					
1900, ...	1,500,100	.83	2.5712	.1906	.1338	9.53	0.42	.0106	1.31	349,400
1901, ...	1,406,900	.81	3.1645	.2228	.1353	9.44	2.40	.0132	1.57	87,300

Effluent of Filter No. 136.

1900, ...	890,800	.56	2.3695	.1301	.1107	9.54	1.72	.0204	1.06	69,700
1901, ...	1,402,700	.82	3.4153	.2331	.1344	8.62	2.00	.0086	1.67	73,000

Sewage applied to Filter No. 135.

[Parts per 100,000.]

1902.	Temperature (Deg. F.).	Ammonia.			Chlorine.	Oxygen Consumed.	Bacteria per Cubic Centimeter
		Free.	Albuminoid.				
			Total.	In Solution.			
January,	52	4.85	.36	.26	7.50	2.41	281,000
February,	51	5.05	.40	.31	6.63	2.32	514,700
March,	56	5.60	.25	.21	6.98	1.50	530,300
April,	54	4.20	.23	.20	9.46	1.65	301,700
May,	59	7.07	.31	.23	9.20	1.56	248,300
June,	67	5.83	.40	.22	9.93	2.25	663,300
July,	68	6.50	.45	.36	10.07	2.48	844,500
August,	66	5.50	.24	.19	10.55	1.42	-
September,	64	4.95	.34	.23	8.24	1.76	985,000
October,	54	4.30	.43	.20	7.98	2.48	1,074,700
November,	55	5.48	.45	.28	8.64	3.19	935,000
December,	51	4.40	.44	.27	6.79	2.42	838,700
Average,	58	5.31	.36	.25	8.50	2.12	656,100

Sewage applied to Filter No. 136.

1902.	Temperature (Deg. F.).	Ammonia.			Chlorine.	Oxygen Consumed.	Bacteria per Cubic Centimeter
		Free.	Albuminoid.				
			Total.	In Solution.			
January,	50	5.28	.48	.36	7.18	2.60	930,000
February,	50	6.00	.48	.38	6.91	2.63	890,000
March,	55	6.15	.38	.27	7.36	2.16	1.030,000
April,	54	4.77	.35	.23	8.55	2.03	940,000
May,	60	7.13	.38	.27	9.45	2.64	1,063.300
June,	67	6.87	.35	.29	11.62	2.64	1,010,000
July,	68	8.75	.41	.31	10.02	2.52	280,000
August,	68	6.60	.26	.19	13.45	2.24	-
September,	65	5.50	.40	.27	70.03	2.32	567,000
October,	64	3.50	.37	.22	11.20	2.85	1,346,500
November,	52	4.28	.50	.30	10.80	3.42	1,532,000
December,	44	3.16	.39	.26	6.94	3.14	1,721,000
Average,	58	5.67	.40	.28	14.46	2.60	1,028,164

Effluent of Filter No. 135.

[Parts per 100,000.]

1902.	Quantity Applied. — Gallons per Acre Daily for Seven Days in a Week.	TEMPERATURE. DEG. F.		Turbidity.	Color.	AMMONIA.			Chlorine.	NITROGEN AS		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Sewage.	Effluent.			Free.	ALBUMINOID. Total.	ALBUMINOID. In Solution.		Nitrates.	Nitrites.		
January, .	1,386,500	52	52	V. slight.	.58	1.6222	.1533	.0856	7.21	2.85	.0090	1.25	3,850
February, .	1,374,300	51	50	V. slight.	.58	1.9625	.1510	.0795	6.49	2.79	.0054	1.24	26,800
March, .	860,600	56	53	V. slight.	.48	1.7520	.1507	.0880	7.65	2.88	.0089	1.11	24,900
April, .	1,630,800	54	54	Slight.	.40	1.2900	.1113	.0633	8.99	1.70	.0103	0.84	13,400
May, . .	1,607,700	59	57	Slight.	.48	1.6800	.1747	.0840	9.33	4.62	.0057	1.22	35,300
June, .	2,229,300	67	65	Slight.	.55	1.2267	.1880	.1013	9.58	4.61	.0060	1.37	26,400
July, . .	2,250,400	68	68	Slight.	.68	3.1100	.2260	.1220	10.01	1.92	.0090	1.66	48,900
August, .	1,725,400	66	64	V. slight.	.43	1.6800	.0880	.0600	10.22	3.35	.0600	0.70	–
September,	1,974,800	64	63	V. slight.	.56	2.4500	.1460	.1000	10.15	2.01	.0083	1.12	118,800
October, .	2,334,500	54	53	Slight.	.45	1.1917	.1100	.0913	8.05	2.32	.0054	0.79	122,900
November,	2,314,700	55	55	V. slight.	.44	1.0300	.0700	.0650	9.19	2.83	.0078	0.74	44,400
December,	2,120,000	51	49	V. slight.	.62	1.9470	.1016	.0872	6.46	1.19	.0067	0.86	37,700
Average,	1,817,400	58	57	–	.52	1.7452	.1392	.0856	8.61	2.76	.0071	1.08	45,760

Effluent of Filter No. 136.

January, .	1,498,700	50	51	V. slight.	.64	2.0844	.1520	.0949	7.30	2.72	.0091	1.17	8,500
February, .	1,511,400	50	49	V. slight.	.68	3.6300	.1470	.1090	6.77	2.09	.0100	1.16	19,700
March, .	912,300	55	54	V. slight.	.48	1.6500	.2080	.1020	7.43	4.62	.0069	1.19	38,500
April, .	1,488,500	54	53	V. slight.	.41	1.0233	.1053	.0767	8.05	2.46	.0107	0.79	13,500
May, . .	1,508,900	60	57	Slight.	.62	2.7067	.2880	.1093	9.08	3.55	.0063	1.81	37,800
June, . .	2,137,100	67	65	Slight.	.70	2.7467	.2640	.1333	11.08	3.51	.0090	1.61	59,400
July, . .	2,068,100	68	69	Slight.	.75	5.1500	.2395	.1770	9.75	1.97	.0090	1.69	153,500
August, .	2,036,200	68	64	Slight.	.43	1.9200	.3360	.0820	13.25	5.29	.0040	2.22	–
September,	2,093,000	65	63	Slight.	.68	2.6600	.1660	.1060	9.98	1.80	.0120	1.27	22,500
October, .	2,286,400	64	53	Decided.	.66	1.6400	.1333	.1053	9.08	1.03	.0076	1.20	175,100
November,	2,195,300	52	56	V. slight.	.51	1.5400	.1630	.0820	8.77	1.61	.0150	1.18	47,900
December,	1,973,500	44	49	V. slight.	.63	1.5120	.1144	.0824	8.12	1.26	.0090	1.01	22,000
Average,	1,809,100	58	57	–	.60	2.3553	.1930	.1050	9.06	2.66	.0091	1.36	54,400

The following tables give the average amount of solid matter in the sewage applied to and the effluents from these two filters: —

Average Solids in Sewage applied to Strainer E.

[Parts per 100,000.]

1902.	UNFILTERED.			FILTERED.			IN SUSPENSION.		
	Total.	Loss on Ignition.	Fixed.	Total.	Loss on Ignition.	Fixed.	Total.	Loss on Ignition.	Fixed.
June, . . .	87.2	47.2	40.0	49.9	19.5	30.4	37.3	27.7	9.6
July, . . .	72.6	34.4	38.2	50.9	17.8	33.1	21.7	16.6	5.1
August, . .	59.0	18.4	40.6	52.8	14.8	38.0	6.2	3.6	2.6
September, .	73.5	35.5	38.0	57.1	21.5	35.6	16.4	14.0	2.4
October, . .	72.8	34.8	38.0	46.8	15.7	31.1	26.0	19.1	6.9
November, .	73.4	35.6	37.8	54.0	18.9	35.1	19.4	16.7	2.7
December, .	56.5	24.2	32.3	42.5	15.6	26.9	14.0	8.6	5.4
Average, .	70.7	32.9	37.8	50.6	17.7	32.9	20.1	15.2	4.9

Average Solids in Effluent of Strainer E.

June, . . .	49.7	15.3	34.4	44.3	13.1	31.2	5.4	2.2	3.2
July, . . .	56.5	21.9	34.6	53.9	19.7	34.2	2.6	2.2	0.4
August, . .	49.0	13.4	35.6	48.0	10.4	37.6	1.0	3.0	–
September, .	49.3	17.6	31.7	45.7	16.2	29.5	3.6	1.4	2.2
October, . .	48.7	19.7	29.0	42.3	17.5	24.8	6.4	2.2	4.2
November, .	58.0	27.4	30.6	51.5	24.0	27.5	6.5	3.4	3.1
December, .	41.6	16.1	25.5	34.6	12.7	21.9	7.0	3.4	3.6
Average, .	50.4	18.8	31.6	45.8	16.2	29.6	4.6	2.5	2.8

Average Solids in Effluent of Filter No. 135.

June, . . .	74.5	23.2	51.3	61.3	16.7	44.6	13.2	6.5	6.7
July, . . .	68.7	19.1	49.6	52.5	10.4	42.1	16.2	8.7	7.5
August, . .	58.8	12.8	46.0	54.2	12.6	41.6	4.6	0.2	4.4
September, .	51.7	13.2	38.5	47.9	11.2	36.7	3.8	2.0	1.8
October, . .	44.2	9.9	34.3	43.3	9.2	34.1	0.9	0.7	0.2
November, .	48.0	8.9	39.1	–	–	–	–	–	–
December, .	36.2	10.8	25.4	–	–	–	–	–	–
Average, .	54.6	14.0	40.6	–	–	–	7.7	3.6	4.1

Average Solids in Septic Sewage applied to Filter No. 136.

[Parts per 100,000.]

1902.	Unfiltered.			Filtered.			In Suspension.		
	Total.	Loss on Ignition.	Fixed.	Total.	Loss on Ignition.	Fixed.	Total.	Loss on Ignition.	Fixed.
June, . . .	54.1	19.7	34.4	51.7	18.6	33.1	2.4	1.1	1.3
July, . . .	58.7	20.9	37.8	55.1	17.7	37.4	3.6	3.2	0.4
August, . .	60.6	17.2	43.4	60.0	14.8	45.2	0.6	2.4	-
September, .	55.0	19.3	35.7	50.0	16.5	33.5	5.0	2.8	2.2
October, . .	58.3	23.5	34.8	46.6	15.1	31.5	11.7	8.4	3.3
November, .	61.7	28.3	33.4	52.1	19.7	32.4	9.6	8.6	1.0
December . .	51.1	25.4	25.7	41.7	18.9	22.8	9.4	6.5	2.9
Average, .	57.1	22.1	35.0	51.0	17.3	33.7	6.0	4.7	1.8

Average Solids in Effluent of Filter No. 136.

June, . . .	67.8	18.3	49.5	60.2	11.9	48.3	7.6	6.4	1.2
July, . . .	68.3	25.3	43.0	50.0	10.9	39.1	18.3	14.4	3.9
August, . .	116.6	23.8	92.8	82.4	14.4	68.0	34.2	9.4	24.8
September, .	51.5	14.5	37.0	45.9	9.9	36.0	5.6	4.6	1.0
October, . .	42.6	12.5	30.1	38.5	9.3	29.2	4.1	3.2	0.9
November, .	47.3	12.2	35.1	40.7	8.1	32.6	6.6	4.1	2.5
December, .	40.2	10.0	30.2	39.5	9.6	29.9	0.7	0.4	0.3
Average, .	62.0	16.7	45.3	51.3	10.6	40.4	11.0	6.1	4.9

Refiltration of Effluents of Filters Nos. 135 and 136, — Filter No. 185.

Filter No. 185 is $\frac{1}{10000}$ of an acre in area, and is constructed of 5 feet in depth of sand of an effective size of 0.23 millimeter. The mixed effluents of Filters Nos. 135 and 136 have been applied to this filter during the year at an average rate of 800,000 gallons per acre daily, and a clear, odorless, non-putrescible effluent, high in nitrates, has been obtained. The average analysis of this effluent for the year has been as follows: —

Effluent of Filter No. 185.

[Parts per 100,000.]

Temperature. Deg. F.		Color.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
Sewage.	Effluent.		Free.	Albuminoid.		Nitrates.	Nitrites.		
57	55	.42	.8355	.0613	9.14	3.56	.0401	.61	17,865

Treatment of Crude Sewage in an Intermittent Continuous Filter, — Filter No. 189.

Filter No. 189, $\frac{1}{20000}$ of an acre in area, contains 10 feet in depth of broken brick about 2 inches in diameter, and has been operated since May 14, 1902. It has received untreated sewage at an average rate of 2,300,000 gallons per acre daily, and has produced a turbid effluent, containing high free and albuminoid ammonia, but with a considerable amount of nitrates. The average analyses of the sewage applied to and the effluent from this filter follow: —

Sewage applied to Filter No. 189.

Quantity Applied. — Gallons per Acre Daily.	Temperature. Deg. F.	Color.	Ammonia.			Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
			Free.	Albuminoid.			Nitrates.	Nitrites.		
				Total.	In Solution.					
-	62	-	3.9100	.5400	.2500	10.56	-	-	3.41	1,591,300

Effluent of Filter No. 189.

2,301,700	59	.90	2.3134	.3569	.1515	10.64	.98	.0537	2.21	452,800

Discussion of Intermittent Continuous Filtration through Coarse Materials.

The results given on the preceding pages, as well as the various tests of effluents, sediment, etc., described and discussed in an article on "The Stability of Effluents of Sewage Filters of Coarse Material," given in the report of the Board for 1901, and continued during 1902 and summarized beyond, show the remarkably satisfactory results that can be obtained by these coarse filters when operating at rates as high as 2,000,000 gallons per acre daily. Effluents are produced with the organic matters in solution in the sewage quite thoroughly oxidized or nitrified, and the suspended matters changed to an innocuous, non-putrefying form. The effluents from Filters Nos. 135, 136 and 189 are now allowed to pass into settling tanks, so that the suspended matters may separate out. There is also added to these tanks at their outlet an upright coke strainer; that is, a few inches in depth of coke, contained within a frame. This is hardly needed, however, as the suspended matter settles rapidly, and this outlet strainer accumulates matter very slowly. The effluents from these settling tanks are generally clear, with very little odor, high in nitrates, and non-putrescible. Many tests made with the sediments have shown their great stability; in character and appearance they are very different from sewage sediment. During the past year analyses of some of these sediments and sewage sediment have been made, and the results are here given. The effluent sediments are of average samples collected from the deposits of many days of operation.

Loss on Ignition, Total Nitrogen, Phosphoric Acid and Sulphuric Acid in the Sediments from Some of the Coarse Filters and from Sewage. (Results expressed in Percentages of Weight.)

	Loss on Ignition.	Total Nitrogen.	Phosphoric Acid. (P_2O_5)	Sulphuric Acid. (SO_3)
Sewage,	66.7	3.63	1.15	.43
Filter No. 134,	16.5	0.80	1.63	.00
Filter No. 135,	28.7	1.55	2.68	.67
Filter No. 136,	32.6	1.94	4.13	.36

All the determinations were made upon the samples dried at 100° C. The total nitrogen was determined by the Gunning modification of the Kjeldahl process. A duplicate determination was also made, modified so as to include the nitrogen as nitrates, if any were present. The results were practically the same as those obtained by the method in which no nitrogen as nitrates was determined.

Other analyses at a different time gave the following results: —

Analyses of Sewage, Dried Sludge and of Sediments from Filters Nos. 135 and 136.

	Sewage Sludge.	Sediment from Filter No. 135.	Sediment from Filter No. 136.
Per cent. by weight of total nitrogen (Kjeldahl),	2.37	1.37	1.41
Per cent. of nitrogen (albuminoid ammonia),	1.30	0.70	0.78
Per cent. that nitrogen by albuminoid ammonia test is of nitrogen (Kjeldahl),	55.00	51.00	55.30
Albuminoid ammonia (parts per 100,000),	1575.50	890.90	952.50
Loss on ignition (per cent. by weight),	58.48	27.63	31.49

Comparison of the Effluents of Contact and Intermittent Continuous Filters.

These filters have varied in depth from 2 feet in the case of a contact filter, to 17 feet 10 inches in the case of intermittent continuous filters, and the method of operation followed has varied greatly. The principal filtering materials used have been coke, cinders and broken stone. The sewage applied has varied from the regular station sewage to sewage in an advanced state of putrefaction, such as that from Septic Tank B and the Andover septic tank. The quality of the various effluents produced by these filters has also varied greatly. The most satisfactory effluent produced by contact filters of coarse material, taking into account the rate of filtration, has been from Filter No. 103, containing 5 feet in depth of coke, and receiving septic sewage. Other contact filters of rough material have given well-nitrified, non-putrefactive effluents, especially those receiving sewage which has had a preliminary treatment.

The studies have shown that, notwithstanding the intermittent continuous filter of coarse material is more difficult to operate, on account of the necessity of uniform distribution of the sewage over the surface, yet with the sewage experimented with at Lawrence such filters can be operated at higher rates than contact filters, and give better results; that is, nitrification within them is normally more active, and, while their effluents generally contain considerable matter in suspension, it is less putrescible than that in the effluents of any but the best contact filters, and settles more readily, leaving a clear liquid.

An interesting and practical point in this comparison is that, while much of the matter in suspension in the sewage is held by both the contact and the intermittent continuous filters for a time, yet it accumulates more slowly within the intermittent continuous filter: for, when reaching a certain degree of change from bacterial oxidation, it falls off from the filtering material in flakes, and appears in the effluent. In the contact filter, on the other hand, this tendency to loosen from the material is less marked. It is also worthy of note that a comparatively smooth material, such as gravel stones or broken stone, gives good results when used in intermittent continuous filters; while, as stated previously, contact filters, to give satisfactory results, need to be constructed of coke or some similar rough and porous material.

The following table shows the average amount of mineral and organic matter in station sewage, strained and septic sewage, and in the effluents of two intermittent continuous and three contact filters. The effluent of Septic Tank A has been applied to Filter No. 103; the effluent of Strainer E to Filter No. 135, and the effluent of Coal Strainer F to Filter No. 175, while Filter No. 176 received the regular untreated station sewage.

Average Solids in Sewage applied to and Effluents from Filters Nos. 103, 175, 176, 135, and 136, June, 1902, to December, 1902.

	UNFILTERED.			FILTERED.			IN SUSPENSION.		
	Total.	Loss on Ignition.	Fixed.	Total.	Loss on Ignition.	Fixed.	Total.	Loss on Ignition.	Fixed.
Sewage for Septic Tank A,	76.9	37.7	39.2	53.7	19.9	33.8	23.2	17.8	5.4
Effluent of Septic Tank A, .	59.7	24.4	35.3	49.0	16.5	32.5	10.7	7.9	2.8
Effluent of Filter 103, . .	47.1	9.8	37.3	44.8	8.7	36.1	2.3	1.1	1.2
Sewage for Strainer E, .	70.7	32.9	37.8	50.6	17.7	32.9	20.1	15.2	4.9
Effluent of Strainer E, . .	50.4	18.8	31.6	45.8	16.2	29.6	4.6	2.5	2.8
Effluent of Filter 135, . .	54.6	14.0	40.6	-	-	-	7.7	3.6	4.1
Sewage for Filter 136, . .	57.1	22.1	35.0	51.0	17.3	33.7	6.0	4.7	1.8
Effluent of Filter 136, . .	62.0	16.7	45.3	51.3	10.6	40.7	11.0	6.1	4.9
Sewage for Coal Strainer, .	72.1	32.2	39.9	53.0	17.3	35.7	19.0	14.9	4.1
Effluent of Coal Strainer, .	63.7	26.2	37.5	52.7	18.0	34.7	11.0	8.3	2.7
Effluent of Filter 175, . .	53.0	13.3	39.7	51.3	12.2	39.1	1.6	1.1	0.9
Effluent of Filter 176, . .	48.4	12.9	35.5	44.5	10.7	33.8	3.9	2.2	1.7

THE STABILITY OF EFFLUENTS OF CONTACT AND INTERMITTENT CONTINUOUS FILTERS.

In the report of the Board for 1901 there was an article on this subject, and the statement was made that "the effluents produced, either by intermittent continuous or by the best contact filters, show little tendency to change when maintained at a summer temperature for a considerable period with the exclusion of air. When mixed with water containing oxygen, they invariably improve in quality." Experimental work and incubation tests to study this subject further have been continued during 1902. Beginning in June, weekly samples of the effluents of contact Filters Nos. 103, 137, 175 and 176 have been incubated, and also the effluents of intermittent continuous Filters Nos. 135, 136 and 189. Duplicate samples of approximately 250 cubic centimeters of each of the effluents of these various filters have been collected at the outlet. In one of these samples determinations of turbidity, sediment, odor, oxygen consumed and dissolved oxygen have been made immediately; while the other has been placed, tightly stoppered, in an incubator, maintained at a temperature of 80° F., and allowed to remain there for five days, at the end of which time the same determinations have been made.

Of the nineteen samples of the effluent of contact Filter No. 103 tested in this way, three increased in odor and two in oxygen consumed; that is, in only three of the nineteen samples did anaerobic or putrefactive action occur, even when undergoing this severe test. In nearly all of them the dissolved oxygen present when they were placed in the incubator had disappeared at the end of the period of incubation. This filter is constructed of broken coke and receives septic sewage, and, as stated previously in this report, has given the best effluent of any contact filter in operation at the station.

Contact Filter No. 137, constructed of broken stone of the same depth as Filter No. 103, was operated at practically the same rate, but received untreated sewage. Nitrification was generally feeble in this filter, and its effluent, on incubation, increased in odor, showing anaerobic changes eleven times out of fourteen tests made. The oxygen consumed was increased at the end of the period of incubation six times in the fourteen tests made. The dissolved oxygen present at first had invariably disappeared at the end of the period.

Filter No. 175, constructed of coke, and receiving sewage which had first been passed through a coal strainer, gave an effluent of which only one sample of twelve increased in odor. In none of these samples was the oxygen consumed increased. In most of them the dissolved oxygen present at the beginning of the period of incubation had disappeared at its end.

The effluent of contact Filter No. 176, constructed of coke, and receiving untreated sewage of the same character as that applied to Filter No. 137, just mentioned, showed upon incubation an increase in odor of four of the twelve samples incubated. In three of the samples the oxygen consumed had increased and in all of them the dissolved oxygen had disappeared at the end of the period of incubation.

Summarizing, it can be said that, while the effluents of contact Filters Nos. 103, 175 and 176, of rough material, were of such a character that anaerobic changes occurred in a few samples, still these changes were not very marked, and the increase in oxygen consumed was but slight. The effluent of contact Filter No. 137, constructed of broken stone, however, was of so poor a quality that generally, when a change occurred during incubation, hydrogen sulphide was developed, and the increase in oxygen consumed was very marked.

The effluents of intermittent continuous Filters Nos. 135, 136 and 189 were submitted to the same tests.

Of the twenty samples of the effluent of Filter No. 135, receiving sewage which has passed through a coal strainer, which were incubated, not one showed an increase of odor at the end of the period, and only one an increase in oxygen consumed. In a number of these samples dissolved oxygen was present at the end of the period.

Of the twenty samples of effluent of Filter No. 136, receiving septic sewage, incubated from the beginning of June to the end of December, only one showed an increase in odor during incubation, and only one an increase in oxygen consumed. In a number of these samples dissolved oxygen was present at the end of the period.

The effluent of intermittent continuous Filter No. 189 was also tested in this way. This filter received untreated sewage, in distinction from Filters Nos. 135 and 136, which received strained and septic sewage, respectively, and is constructed of coarse material. With Filter No. 189, eleven of the nineteen samples of effluent incubated showed an increase in odor at the end of the period, this odor sometimes being offensive, and five showed an increase in oxygen consumed. In only two instances was dissolved oxygen present in the sample at the end of the period.

Nitrogen in Applied Sewage and in Effluents.

The determination of nitrogen in the various forms in which it occurs in sewage and in the effluents of the filters affords a ready means of tracing the changes which the organic matter undergoes in passing through the filters. There may be also considerable organic matter stored within a filter, even when the filter is in good working condition. This, when not due to overworking a filter, is probably the portion least susceptible to bacterial action. Much work has been carried out and many calculations made upon this subject of storage of nitrogen, and tables have been given in various reports showing the proportion of total nitrogen in the sewage applied not appearing in the effluents and not remaining stored in the filters.

In the extended series of investigations which were made to trace the nitrogen of the sewage as it passes through the filter in intermittent sand filtration it was discovered that a varying percentage of the nitrogen was unaccounted for, not being found in the effluent and not being stored in the filter. The inference was either that the nitrogen escaped as such into the air, or was in such a form that it eluded our processes of analysis. Subsequent investigations point directly to its loss in the gaseous state. Later experience has also shown that the proportion of nitrogen unaccounted for varies with different kinds of filters and with differently constructed or operated filters of the same kind.

The following tables present some interesting data on this subject obtained during the last two years. Filters Nos. 1, 2, 6 and 9A are the oldest intermittent sand filters at the station, and No. 5B is an intermittent ash and cinder filter. For the period shown in the tables, the percentage of nitrogen in the applied sewage not appearing in the effluents from these filters amounted to 12, 16, 4, 9 and 13 per cent., respectively. Filters Nos. 135 and 136 are intermittent continuous filters, and from the tables given on page 212 it will be seen that only 2 and 3 per cent., respectively, of the nitrogen applied to them is unaccounted for. With Filter No. 176 (see page 211), a contact filter, more than 50 per cent. is unaccounted for; and with Filter No. 175, also a contact filter, 33 per cent. is unaccounted for. Filter No. 100, an intermittent sand filter receiving septic sewage, shows a loss of 15 per cent.

The results of these determinations and calculations may not, when applied to contact filters, be as accurate as those obtained from intermittent and intermittent continuous filters, owing to the greater difficulty in sampling the effluents; but there is no doubt of the fact that the nitrogen unaccounted for in the operation of contact filters is very much larger than from the other filters. Characteristic of the operation of contact filters is the large reduction of the free ammonia of the sewage without equivalent increase in nitrates and nitrites in the effluent.

The fact that all the nitrogen is accounted for in those filters of coarse material in which we are sure that oxidizing conditions exist throughout, — Filters Nos. 135 and 136, — and the fact that the formation of hydrocarbons and free nitrogen is characteristic of the action of the septic tank, lead to the inference that when a loss of nitrogen occurs it is the result of anaerobic action in a filter. In the experiments on the nitrification of a soluble salt of ammonia and of a soluble nitrogenous substance, — petone (described in the special report of 1890), — it was found that all of the nitrogen was accounted for in the effluents. In these experiments no solid matter was applied to the filter, and it is reasonable to suppose that oxidizing conditions existed throughout the whole body of the sand.

Average of Total Nitrogen in Sewage applied to and in Effluents of Sewage Filters, July, 1901, to June, 1902, inclusive.

[Parts per 100,000.]

1901.	Average Sewage for Filters Nos. 1 and 2.	Effluent of Filter No. 1.	Effluent of Filter No. 2.
July,	3.9609	5.3374	4.6061
August,	4.4310	3.8000	4.0172
September,	5.2796	4.8590	5.1418
October,	4.7687	2.9468	4.0564
November,	6.7453	2.0406	2.4188
December,	4.8017	3.3719	1.2373
1902.			
January,	4.5456*	3.5943	2.7051
February,	4.8095	3.5672	3.7600
March,	3.9201	3.9900	3.6360
April,	4.4556	5.9703	4.2449
May,	5.1227	7.0642	5.6017
June,	5.1964	4.5235	6.1944
Average,	4.8364	4.2555	4.0516

* Average sewage for Nos. 1, 6 and 9A all the same after Jan. 1, 1902.

1901.	Average Sewage for Filters Nos. 5B and 6.	Effluent of Filter No. 5B.	Effluent of Filter No. 6.
July,	3.9120	5.0632	6.2054
August,	4.9741	3.7306	4.0553
September,	4.5952	4.7638	4.8105
October,	5.5425	4.2643	3.5470
November,	7.0832	4.2654	2.3158
December,	4.5624	3.6503	2.8021
1902.			
January,	4.5456*	4.7114	2.9025
February,	4.8095	4.1050	4.1127
March,	3.9201	3.7851	3.7307
April,	4.4556	4.2098	4.8982
May,	5.1227	3.8640	9.3426
June,	5.1864	4.5675	5.6416
Average,	4.8933	4.2433	4.6137

* Average sewage for Nos. 1, 6 and 9A all the same after Jan. 1, 1902.

1901.	Average Sewage for Filter No. 9A.	Effluent of Filter No. 9A.
July,	4.1918	7.0018
August,	4.6121	4.5734
September,	4.7852	4.1765
October,	5.1062	2.8268
November,	7.5456	3.6910
December,	4.6216	4.2641
1902.		
January,	4.5456*	3.4560
February,	4.8095	3.4117
March,	3.9201	3.9367
April,	4.4556	4.8719
May,	5.1227	7.9636
June,	5.1964	4.4495
Average,	4.9092	4.5519

* Average sewage for Nos. 1, 6 and 9A all the same after Jan. 1, 1902.

The following table shows the small percentage of nitrogen of the applied sewage present in the effluents of the contact filters, and illustrates the loss of nitrogen of the free ammonia, as discussed on page 213 : —

Averages of Total Nitrogen in Sewage applied to and Effluents from Contact Filters Nos. 175 and 176, from July 1, 1901, to June 30, 1902.

[Parts per 100,000.]

1901.	Sewage applied to Filter No. 175. (Effluent of Coal Strainer.)	Effluent of Filter No. 175.	Regular Sewage applied to Filter No. 176.	Effluent of Filter No. 176.
July,	–	2.3535	3.7623	2.4034
August,	4.82	2.3752	4.7326	2.1866
September,	4.00	1.9930	5.3604	1.7373
October,	4.91	3.4369	5.1868	3.6541
November,	4.51	4.2342	6.8517	1.6537
December,	3.13	2.8740	3.8627	2.0620
1902.				
January,	4.56	2.7630	4.6036	2.3411
February,	4.62	3.1564	4.5134	2.5723
March,	3.28	2.5577	3.8045	1.5022
April,	4.38	3.0564	4.6367	1.8199
May,	5.92	3.5645	4.7108	2.6863
June,	5.08	3.5396	5.0234	1.8670
Average,	4.48	2.9920	4.7545	2.2072

Averages of Total Nitrogen in Sewage applied to and Effluents from Intermittent Continuous Filters Nos. 135 and 136, from July 1, 1901, to June 30, 1902.

[Parts per 100,000.]

1901.	Sewage applied to Filter No. 135.	Effluent of Filter No. 135.	Sewage applied to Filter No. 136.	Effluent of Filter No. 136.
July,	4.8184	4.4281	4.4936	4.2602
August,	6.2674	6.4149	6.0200	5.9555
September,	5.5590	5.2669	5.5703	4.9665
October,	7.0243	7.2663	6.0200	6.4101
November,	7.0420	7.1937	6.4491	6.5133
December,	3.8300	3.9644	3.9757	3.6376
1902.				
January,	4.5873	4.4476	5.1398	4.6952
February,	4.8183	4.6610	5.7319	5.3315
March,	5.0234	4.5897	5.6912	6.3293
April,	3.8380	2.9563	4.5050	3.4871
May,	6.3331	6.2968	6.4982	6.2603
June,	5.4601	5.9361	6.2345	6.2164
Average,	5.3834	5.2852	5.5274	5.3386

Averages of Total Nitrogen in Septic Sewage applied to and Effluents of Filters Nos. 100 (Sand) and 103 (Contact), from July 1, 1901, to June 30, 1902.

[Parts per 100,000.]

1901.	Sewage applied to Filters Nos. 100 and 103.	Effluent of Filter No. 100.	Effluent of Filter No. 103.
July,	3.58	3.6788	3.3396
August,	4.39	3.7227	3.4288
September,	4.60	4.4781	4.1189
October,	4.63	3.7995	4.1186
November,	4.98	4.0538	4.9788
December,	3.52	2.5019	2.4484
1902.			
January,	4.27	2.8889	3.4070
February,	3.92	3.4547	2.4159
March,	3.90	2.3736	2.2462
April,	4.39	2.3762	3.6790
May,	4.49	4.7975	2.5633
June,	4.32	5.3532	2.5270
Average,	4.25	3.6232	3.2726

LOSS OF NITROGEN IN CONTACT FILTRATION, COMPARED WITH THE LOSS IN INTERMITTENT CONTINUOUS FILTRATION.

On previous pages tables have been given, showing the percentage of the nitrogen in the sewage applied to certain filters that appears in their effluents. It was noted in discussing these tables that there appeared to be a great loss of nitrogen in contact filtration. It was also stated that this might be partly due to the impossibility of obtaining as representative samples from these filters as from intermittent sand and intermittent continuous filters; but this would only give misleading figures in regard to the nitrogen determined as albuminoid ammonia. This loss is largely, however, of the nitrogen found as free ammonia in the sewage and not appearing as free ammonia or in the form of nitrates or nitrites in the effluent of these filters; that is, a much larger percentage of the nitrogen of the free ammonia of the sewage must pass into the air from contact filters than is the case in the operation of other filters. The following figures prove this.

Taking contact Filters Nos. 103, 175 and 176, and the Andover contact filter, all constructed of coke, and comparing the analyses of the applied sewage and effluents during 1902, we find that their effluents contained respectively 69, 71, 68 and 49 per cent. less free ammonia than the sewage applied to them. We find also that the amount of nitrogen as free ammonia nitrates and nitrites in their effluents amounted to only 62, 74, 50 and 50 per cent., respectively, of the nitrogen as free ammonia in the sewage applied; that is to say, with these filters 38, 26, 50 and 50 per cent., respectively, of the nitrogen applied as free ammonia has been lost into the air, even assuming that all the nitrogen found as nitrates and nitrites in these effluents came from the free ammonia of the applied sewage. The only nitrogen of the sewage stored in the filter is that applied in the organic matter represented in the analyses as albuminoid ammonia. With intermittent continuous Filters Nos. 135 and 136 a similar comparison of effluent and sewage analyses shows that in each instance 98.6 and 98.9 per cent. of the nitrogen as free ammonia appeared in the form of free ammonia, nitrates or nitrites in their effluents, or a disappearance of only about 1 per cent. The reduction of free ammonia by filtration was about the same as with the contact filters, namely, 67 and 58 per cent., respectively.

These figures, taken in connection with the regular analyses and incubation tests of contact filter effluents, tend to show that high nitrification is not absolutely necessary in obtaining good effluents from this class of filters. Anaerobic action occurring during each daily period of rest is probably accountable for this loss of nitrogen; and the nature of the filtering material also plays a part, a greater loss occurring from contact filters of rough and porous material than from contact filters of broken stone. In the intermittent continuous filters, where aerobic action always prevails, there apparently is no loss of nitrogen.

OPERATION OF THE LARGE INTERMITTENT FILTERS, $\frac{1}{200}$ OF AN ACRE IN AREA.

The effluents of most of these large filters have during portions of the past two years been of a comparatively poor quality. The poor results during the winter of 1900-1901 were largely due to a break in the sewer pipe, preventing the application of sewage for three weeks in December. This caused nitrification to cease, and it was not re-established until warm weather. During the winter of 1901–1902 nitrification in these filters was again very feeble. Notwithstanding this, their effluents, instead of becoming turbid and being subject to putrefaction, were clear, comparatively low in albuminoid ammonia, and would remain without change, even when incubated at 80° F. for five days. The cause of this poor nitrification and its slow establishment in spring, with the consequent high free ammonia in the effluents of these filters, has not been definitely determined. The filters were apparently in good physical condition during this period, and the applied sewage disappeared as readily as during previous years. It is possible that spading these filters over many times to the same depth has caused a condition similar to stratification, and that in the winter, when organic matter accumulates at this depth, a reducing action occurs in the lower portion of the filter. That this is true to some extent would be inferred from the considerable amounts of iron present in these filters at times during the past two winters.

Early investigations at the station showed that a regular stratification of filtering materials, either with the coarse layer above the fine, or *vice versa*, prevented the free passage of air in the filter. (See Filters Nos. 3A and 5A, reports of 1891 and 1892, in which the materials were purposely stratified.) It seems probable, however, that even in filters of such materials as those in Filters Nos. 1 and 9A, natural stratification, or at least a surface accumulation of fine mineral matter, will sometimes occur to a certain extent after a considerable period of operation. For instance, Filter No. 1 contained originally 5 feet in depth of coarse sand, having an effective size of 0.48 millimeter, and the 9 inches of new sand placed in it during 1893, in place of the clogged sand removed, was of practically the same grade. At the end of 1902 the upper 6 inches of sand in this filter had an average size of 0.30 millimeter, — a reduction in size of 38 per cent. Below 9 inches in depth the sand was of the original grade. While this may not affect materially the summer results, in winter, when partially frozen, an effect may be produced similar to that caused by placing a layer of fine sand above coarse sand in a filter. It can probably be obviated by spading to a greater depth.

During the winter of 1902–1903, when Filter No. 9A had ceased to nitrify, an examination of the sand revealed that, while the upper layers were free from frost, at a depth of 6 inches there was a frozen layer 9 inches in thickness. Careful removal of different layers and analysis showed that, while the upper 6 inches of sand contained an average of 86 parts of nitrogen per 100,000, the sand immediately above the frozen layer contained 97 parts per 100,000. Three inches below this there were only 19 parts of nitrogen per 100,000. This sand at the frost line was, moreover, noticeably darker colored than the sand above. Stratification in this instance was thus shown to be due to the accumulation of organic matter on the top of the tightly frozen layer.

The operation of these filters during the year 1902 was as follows: —

Filter No. 1.

Filter No. 1 contains 60 inches in depth of coarse sand of an effective size of 0.48 millimeter, and is $\frac{1}{200}$ of an acre in area. The surface of this filter has been raked 1 inch deep each week, and spaded over to a depth of 6 inches upon April 1, August 7 and October 4. During January, 8 inches of snow and $3\frac{1}{8}$ inches of ice were removed from the surface; during February, $21\frac{1}{4}$ inches of snow and $3\frac{1}{4}$ inches of ice; during March, $6\frac{1}{2}$ inches of snow; during December, $34\frac{1}{2}$ inches of snow and $\frac{3}{8}$ inch of ice. The filter was allowed to rest from April 1 to April 6, from May 15 to May 19, from August 5 to August 12, and from September 24 to November 10, inclusive. March 1 to March 9 the experiment was interrupted by a freshet.

Filter No. 2.

This filter is $\frac{1}{200}$ of an acre in area, and contains 60 inches in depth of fine sand of an effective size of 0.08 millimeter, with two circular trenches 1 foot wide and 2 feet deep, of medium sand of an effective size of 0.19 millimeter, the surface of these trenches being below the surface of the remainder of the filter, and the sewage being applied to them. The surface of the trenches has been raked 1 inch deep each week, and was spaded to a depth of 6 inches on April 1, August 7 and October 4. During January, 8 inches of snow and $2\frac{1}{2}$ inches of ice were removed from the surface of the filter; during February, $10\frac{1}{4}$ inches of snow and $2\frac{1}{4}$ inches of ice; during March, 7 inches of snow; and during December, $31\frac{1}{4}$ inches of snow and $1\frac{1}{8}$ inches of ice were removed. The filter was allowed to rest from April 1 to April 6, from May 15 to May 19, from August 5 to August 13, and from September 24 to November 10, inclusive. March 1 to March 9 the experiment was interrupted by a freshet.

Filter No. 4.

This filter is $\frac{1}{200}$ of an acre in area, and contains 60 inches in depth of fine river silt of an effective size of 0.04 millimeter, with two circular trenches about 14 inches wide and 12 inches deep, of coarse sand of an effective size of 0.48 millimeter. The surface of these trenches is below the surface of the remainder of the filter, and to them the sewage is applied. They have been raked 1 inch deep each week, and spaded to a depth of 6 inches on March 31, August 7 and October 4. During January, 11 inches of snow and 4 inches of ice were removed from the filter; during February, 15¼ inches of snow and 4⅝ inches of ice; during March, 8 inches of snow; and during December, 17½ inches of snow. The filter was allowed to rest from March 31 to April 6, from May 15 to May 19, from August 5 to August 13, and from September 24 to October 8, inclusive. March 1 to March 9 the experiment was interrupted by a freshet.

Filter No. 5B.

This filter is $\frac{1}{200}$ of an acre in area, and contains 60 inches in depth of a mixture of cinders and ashes from the combustion of soft coal. It was first put into operation March 5, 1898. Owing to the coarseness of the material in this filter, the sewage enters it more readily than it does any of the other large filters, and this is a condition especially favorable for good work during cold winter weather. The surface of the filter has been raked 1 inch deep each week. During January, 13 inches of snow and 1 inch of ice were removed from the surface of the filter; during February, 20½ inches of snow and ½ inch of ice; during March, 9 inches of snow; and during December, 30 inches of snow and ⅞ inch of ice. The filter was allowed to rest from March 31 to April 6, from May 15 to May 19, from August 5 to August 12, and from September 24 to October 8, inclusive. March 2 to March 5 the experiment was interrupted by a freshet.

Filter No. 6.

This filter is $\frac{1}{200}$ of an acre in area, and contains 44 inches in depth of mixed coarse and fine sand of an effective size of 0.35 millimeter. The surface of the filter has been raked to a depth of 1 inch each week, and spaded to a depth of 6 inches on March 31, August 7, and October 4. During January, 12⅛ inches of snow and 5⅝ inches of ice were removed from the surface of the filter; during February, 17½ inches of snow and 1⅝ inches of ice; during March, 8½ inches of snow; and during December, 37¾ inches of snow and ⅝ inch of ice. The filter was allowed to rest from March 31 to April 6, from May 15 to May 19, from August 4 to August 12, and from September 24 to October 7, inclusive. March 1 to March 9 the experiment was interrupted by a freshet.

Filter No. 9A.

This filter is $\frac{1}{200}$ of an acre in area, and contains 5 feet in depth of sand of an effective size of 0.17 millimeter. From January 1 to March 31 the sewage was applied to 2 flat-bottomed trenches, each 7 inches deep, 5 feet wide and 11 feet long. The surface of these trenches was raked 1 inch deep each week. On April 1 the surface of the trenches was spaded over 6 inches deep. The remainder of the surface was spaded a little deeper than the surface of the trenches, and the surface of the whole filter was levelled. Following this, the surface of the filter has been raked an inch deep each week, and has been spaded over to a depth of 6 inches on August 7 and October 4. During January, 11¼ inches of snow and 2¼ inches of ice were removed from the surface of the filter; during February 18½ inches of snow and ½ inch of ice; during March, 6½ inches of snow; and during December, 34 inches of snow. The filter was allowed to rest from March 31 to April 6, from May 15 to May 19, from August 4 to August 12, and from September 24 to October 7, inclusive. March 1 to March 9, March 14 to March 15, and March 18 to March 20, the experiment was interrupted by a freshet.

Filter No. 10.

This filter is $\frac{1}{200}$ of an acre in area, and contains 5 feet in depth of mixed coarse and fine sand of an effective size of 0.35 millimeter. No underdrains are beneath the sand except directly above and around the outlet pipe. A partition extending 3 feet below the surface separates the quarter of the surface farthest from the underdrains from the remainder of the surface. To this quarter of the surface the sewage is applied, and over the remainder of the surface is a layer of loam 8 inches in depth, this keeping the body of the filter freer from frost than is the case with most of the other filters, and hence allowing better nitrification, as a general thing, in the winter weather, this being aided also by the small surface, to which a comparatively large volume of sewage is applied. The surface of the filter has been raked 1 inch deep each week, and spaded to a depth of 6 inches on March 31, August 7 and October 4. During January, 12¼ inches of snow and ⅛ inch of ice were removed from the surface of the filter; during February, 28¼ inches of snow and ½ inch of ice; during March, 7½ inches of snow; and during December, 41½ inches of snow. The filter was rested from March 31 to April 6, from May 15 to May 19, from August 5 to August 12, and from September 24 to October 7, inclusive. March 2 to March 9, March 14 to March 15, and March 18 to March 20, the experiment was interrupted by a freshet.

Effluent of Filter No. 1.

[Parts per 100,000.]

Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature. Deg. F.		Length of Time Sewage Remained on Surface. — Hours and Minutes.	Appearance.		Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
	Sewage.	Effluent.		Turbidity.	Color.	Free.	Albuminoid.		Nitrates.	Nitrites.		
56,600	57	54	49m.	V. slight.	.47	1.9887	.0857	10.48	2.23	.0016	.75	45,670

Effluent of Filter No. 2.

31,200	56	53	1h. 28m.	None.	.40	1.5521	.0518	10.61	2.66	.0012	.56	206

Effluent of Filter No. 4.

19,600	56	54	2h. 28m.	None.	.27	1.2474	.0555	10.00	3.08	.0006	.43	778

Effluent of Filter No. 5B.

116,900	56	55	48m.	V. slight.	.38	1.1610	.0789	10.23	2.91	.0014	.64	32,828

Effluent of Filter No. 6.

58,000	56	55	1h. 56m.	V. slight.	.52	2.1817	.0808	9.86	2.21	.0035	.68	13,420

Effluent of Filter No. 9A.

57,000	57	54	1h. 18m.	None.	.41	1.8780	.0612	10.13	2.30	.0005	.55	8,616

Effluent of Filter No. 10.

26,400	57	53	51m.	None.	.34	0.9124	.0543	9.74	2.60	.0021	.48	5,191

STORAGE OF NITROGEN IN SAND FILTERS.

The following tables present the results of analyses from time to time of the sand at different depths in Filters Nos. 1 and 9A. These analyses show that there has been a slow increase of nitrogen in these filters.

Filter No. 1.— Table showing the Amount of Nitrogen stored in the Sand at Different Depths, calculated from Albuminoid Ammonia Determinations, and deducting the 1 Part of Nitrogen contained in the Original Sand.

[Parts per 100,000 by weight of dry sand.]

DEPTH.	December, 1888.	February, 1889.	June, 1889.	November, 1889.	April, 1890.	June, 1890.	November, 1890.	March, 1891.	June, 1891.	November, 1891.
Average 6 inches, . . .	14.95	31.71	34.73	100.01	36.00	32.52	85.00	74.30	95.30	-
12 " . . .	3.30	3.85	2.90	3.05	6.00	5.30	5.50	12.30	12.20	19.40
18 " . . .	3.20	2.55	2.00	1.75	3.30	2.60	3.80	8.70	6.70	11.90
24 " . . .	3.15	2.40	1.65	1.60	2.70	1.80	2.50	6.30	4.50	7.30
36 " . . .	3.15	2.40	1.20	1.60	1.60	0.50	2.00	2.90	0.40	3.10
48 " . . .	2.70	2.40	1.05	1.15	0.70	0.30	1.00	1.20	2.30	1.90
60 " . . .	1.65	2.40	0.95	0.75	0.40	0.20	0.70	1.10	1.60	1.70

DEPTH.	April, 1893.	December, 1893.	January, 1894.	October, 1895.	March, 1895.	October, 1896.	March, 1896.	May, 1898.	October, 1900.	September, 1901.	November, 1902.
Average 6 inches, .	134.04	80.05	-	45.50	78.67	51.00	-	81.82	81.32	131.76	99.60
12 " .	15.14	33.90	21.50	21.30	15.00	13.00	16.00	18.35	18.81	50.30	16.96
18 " .	17.94	23.10	21.00	14.10	13.60	8.50	10.00	10.64	14.42	16.47	16.27
26 " .	7.90	14.60	17.20	12.90	14.20	6.40	8.90	10.15	10.28	14.97	14.53
36 " .	5.58	9.20	5.90	2.60	4.70	3.40	5.90	4.08	7.95	9.12	14.25
48 " .	5.26	4.20	4.20	2.10	2.80	3.20	3.80	2.11	3.66	5.12	3.05
60 " .	6.90	3.60	3.00	2.30	1.80	2.00	3.40	3.59	5.89	5.00	4.63

Filter No. 9A.— Table showing the Amount of Nitrogen stored in the Sand at Different Depths, calculated from Albuminoid Ammonia Determinations, and deducting the 1.33 Parts of Nitrogen contained in the Original Sand.

[Parts per 100,000 by weight of dry sand.]

DEPTH.	March, 1891.	June, 1891.	November, 1891.	January, 1894.	November, 1894.	March, 1895.	October, 1895.	June, 1898.	October, 1900.	September, 1901.	January, 1903.
Average 6 inches, .	41.63	47.46	69.02	32.87	58.97	76.27	55.14	58.53	103.62	71.13	85.57
12 " .	5.08	3.88	7.00	10.97	11.27	14.47	7.27	12.45	22.92	51.02	19.01
24 " .	3.17	2.09	3.88	7.97	-	10.27	5.67	9.27	11.54	7.57	10.35
24 " .	2.17	1.37	1.59	3.47	7.67	5.87	3.27	5.89	6.02	6.20	7.82
36 " .	1.39	1.56	1.62	2.27	-	5.37	2.07	4.25	5.06	5.92	6.56
42 " .	-	-	-	-	3.27	-	-	-	-	-	-
48 " .	1.39	0.48	0.00	2.47	-	2.77	2.07	3.43	3.97	4.03	4.77
60 " .	0.97	0.00	0.00	1.47	3.27	1.47	2.07	3.26	3.51	5.39	6.31

The following tables present the actual volume of sewage applied to Filters Nos. 1 and 9A since their construction, together with data with regard to nitrogen applied in the sewage,— that found in the effluent, that removed by scraping ten or more years ago, and the amount now stored in the sand of the filter. In these calculations it has been assumed that in all analytical work upon Lawrence sewage and sand 50 per cent. of the total organic nitrogen present is obtained by the albuminoid ammonia process. Recent investigations have shown that this factor is not as accurate as formerly supposed, but its variation is difficult to determine. Whatever factor for albuminoid ammonia value is used, however, the comparative results will be but slightly affected.

Filter No. 1, Jan. 10, 1888, to Nov. 10, 1902.

Gallons of sewage applied since start,	1,674,582.00
Pounds of nitrogen applied in the sewage,	513.62
Pounds of nitrogen in effluent,	385.50
Pounds of nitrogen removed by scraping,	19.23
Pounds of nitrogen stored in sand, Nov. 10, 1902,	21.65
Pounds of nitrogen unaccounted for,	114.24
Per cent. of nitrogen unaccounted for,	22.24

Filter No. 9A, Nov. 18, 1890, to Jan. 23, 1903.

Gallons of sewage applied since start,	1,467,267.00
Pounds of nitrogen applied in the sewage,	462.59
Pounds of nitrogen in effluent,	346.79
Pounds of nitrogen removed by scraping,	14.61
Pounds of nitrogen stored in sand, Jan. 23, 1903,	17.45
Pounds of nitrogen unaccounted for,	83.74
Per cent. of nitrogen unaccounted for,	18.10

The following table shows the amount of nitrogen stored in Filter No. 100 at the end of 1902. This is a sand filter that has been in operation five years, and has always had septic sewage applied to it.

Nitrogen stored in Filter No. 100.

[Parts per 100,000.]

Average first 6 inches,	82.78
Average first 12 inches,	28.78
Average first 18 inches,	16.37
Average first 24 inches,	13.07
Average first 36 inches,	8.69
Average first 48 inches,	11.78
Average first foot,	57.28
Average second foot,	18.65
Average third foot,	10.88
Average fourth foot,	10.24

Nitrogen stored in Filter No. 100 from Jan. 1, 1898, to March 23, 1903.

Gallons of sewage applied,	19,973.00
Pounds of nitrogen applied,	6.74
Pounds of nitrogen in effluent,	6.14
Pounds of nitrogen removed by scraping,	0.26
Pounds of nitrogen stored in the sand,	0.20
Pounds of nitrogen unaccounted for,	0.14
Per cent. of nitrogen unaccounted for,	2.10

EFFECT OF GERMICIDES IN SAND FILTRATION.

In connection with an application to the State Board of Health in regard to the purification of hospital sewage containing disinfectants, three sand filters have been operated with sewage containing phenol, mercuric chloride and formalin, respectively. These filters are each 4½ feet in depth, and contain sand of an effective size of 0.23 millimeter. They are numbered 182, 183 and 184, and have been operated at rates of about 50,000 gallons per acre daily. Following tables show the amount of the germicides added at different times, and the action of the filters under these conditions. Each filter was allowed to reach a condition of good nitrification before the germicides were added.

Phenol was first applied to Filter No. 182 on Dec. 16, 1901, and in the proportion of 1 part to 200 parts of sewage. Nitrification was quickly destroyed, and the effluent of the filter became sterile. The proportion of phenol was reduced from time to time, but not until the amount added was as low as 1 part to 2,667 parts of sewage did nitrification become re-established. Following this, the amount of phenol was increased from time to time. During this increase nitrification was destroyed at one time, but began again without decreasing the proportion of phenol in the applied sewage. At the present time, as shown by the table, an amount of phenol is being added to the filter, without ill effects, that, in the early days of its operation, prevented nitrification.

The amount of mercuric chloride in the sewage applied to Filter No. 183 reached 1 part in 500 before nitrification ceased.

Filter No. 184 is now receiving formalin in the proportion of 1 part to 250 parts of sewage, and maintaining good nitrification. All of the germicides were found in the effluents.

Similar results were obtained early in the operation of the station, when common salt was added in large quantities to a filter in which experiments on the nitrification of ammonium chloride were being made. Nitrification was almost entirely checked when the applied liquid contained 1,200 parts of chlorine per 100,000 as common salt. But when the amount of salt was increased gradually, a nearly saturated solution did not entirely prevent nitrification. These experiments were made to determine the effect of sea water (which contains about 1,800 parts of chlorine per 100,000) on nitrification in sewage filters.

Another instance of the gradual adaptation of bacteria to new conditions is found in the experiments on the nitrification of ammonium chloride. After each increase in amount of this ammonium salt the effluent contained free ammonia, which in a few days disappeared, and nitrification became complete.

Effluent of Filter No. 182.

[Parts per 100,000.]

Date.	Quantity Applied. Gallons per Acre Daily for Six Days in a Week.	Temperature. Deg. F.		Appearance.		Ammonia.		Nitrogen as		Bacteria per Cubic Centimeter.	Proportion of Phenol.
		Sewage.	Effluent.	Turbidity.	Color.	Free.	Albuminoid.	Nitrates.	Nitrites.		
1901.											
November, .	49,500	48	52	None.	.10	3.1750	.0210	0.25	.0585	274,200	- -
December, .	49,500	51	50	None.	.07	3.4800	.0360	2.84	.0028	800	Dec. 16, 1 : 200
1902.											
January, . .	47,700	52	52	None.	-	2.0550	.2445	0.18	.0036	3	Jan. 27, 1 : 267
February, .	49,600	52	52	None.	-	2.9750	.2100	0.02	.0085	0	Feb. 24, 1 : 400
March, . .	34,300	47	56	None.	-	2.7600	.1720	0.01	.0035	23	Mar. 31, 1 : 667
April, . .	49,600	51	56	None.	-	3.4675	.1600	0.01	.0014	107	Apr. 21, 1 : 1,333
May, . .	45,900	58	66	None.	.13	2.1600	.0648	0.03	.0862	3,740	May 12, 1 : 2,667
June, . .	49,500	65	70	None.	.19	1.3050	.0400	4.22	.1498	6,306	June 24, 1 : 2,000
July, . .	49,600	68	73	None.	.11	0.1192	.0244	1.44	.0074	6,140	July 16, 1 : 1,333
August, . .	47,800	69	72	None.	.17	0.0800	.0180	1.46	.0100	300	- -
September, .	38,100	65	65	V. slight.	.07	0.0420	.0167	1.99	.0104	380	Sept. 10, 1 : 1,000
October, . .	38,600	55	58	V. slight.	.22	0.0290	.0585	2.50	.0009	1,198	- -
November, .	49,500	49	61	V. slight.	.67	0.1165	.0305	0.04	.0011	3,855	Nov. 21, 1 : 2,000
December, .	47,700	50	61	V. slight.	.37	0.9200	.0330	2.23	.0107	2,122	- -
1903.											
January, . .	49,560	45	66	V. slight.	.33	0.1136	.0216	2.58	.0040	295	Jan. 7, 1 : 1,500
February, .	50,000	47	67	V. slight.	.31	0.2435	.0215	1.62	.0038	963	- -
March, . .	47,600	48	65	V. slight.	.43	0.3005	.0195	2.29	.0056	336	Mar. 20, 1 : 1,000

Effluent of Filter No. 183.

[Parts per 100,000.]

Date.	Quantity Applied. Gallons per Acre Daily for Six Days in a Week.	Temperature. Deg. F.		Appearance.		Ammonia.		Nitrogen as		Bacteria per Cubic Centimeter.	Proportion of Mercuric Chloride.
		Sewage.	Effluent.	Turbidity.	Color.	Free.	Albuminoid.	Nitrates.	Nitrites.		
1901.											
November, .	49,500	48	52	None.	.13	1.3000	.0210	0.18	.0225	104,100	- -
December, .	49,500	51	50	None.	.11	3.2200	.0420	1.65	.0133	200	Dec. 16, 1 : 10,000
1902.											
January, . .	47,700	52	52	None.	-	1.1800	.0220	1.65	.0101	705	- -
February, .	49,600	52	52	None.	-	0.2550	.0100	3.23	.0115	326	Feb. 24, 1 : 7,500
March, . .	34,300	47	56	None.	-	0.0150	.0100	1.85	.0005	138	Mar. 31, 1 : 5,000
April, . .	49,600	51	56	None.	-	0.0160	.0100	3.30	.0005	51	Apr. 21, 1 : 2,500
May, . .	45,900	58	66	None.	.11	0.0132	.0084	2.87	.0009	738	May 12, 1 : 1,000
June, . .	49,500	65	70	None.	.17	0.5615	.0345	1.93	.0070	160	June 2, 1 : 750 June 24, 1 : 500
July, . .	49,600	68	73	V. slight.	.50	2.1040	.0734	0.09	.0057	0	- -
August, . .	47,800	69	72	V. slight.	.22	1.9200	.0200	0.19	.0040	0	- -
September, .	38,100	65	65	V. slight.	.24	1.6533	.0480	0.14	.0022	2	Sept. 16, 1 : 750
October, . .	38,600	55	58	V. slight.	.33	1.9775	.0405	0.18	.0047	2	Oct. 30, 1 : 1,000
November, .	49,500	49	61	V. slight.	.33	1.7525	.0510	0.13	.0057	1	Nov. 21, 1 : 1,250
December, .	47,700	50	61	V. slight.	.37	2.2325	.0720	0.21	.0093	2	- -
1903.											
January, . .	49,560	45	66	V. slight.	.31	1.7060	.0544	0.35	.0033	38	Jan. 7, 1 : 2,000
February, .	50,000	47	67	V. slight.	.33	1.3900	.0360	0.53	.0060	1,280	- -
March, . .	47,600	48	65	V. slight.	.38	1.3675	.0200	1.85	.0150	252	Mar. 20, 1 : 1,500

Effluent of Filter No. 184.

[Parts per 100,000.]

Date.	Quantity Applied.	Temperature. Deg. F.		Appearance.		Ammonia.		Nitrogen as		Bacteria per Cubic Centimeter.	Proportion of Formalin.
	Gallons per Acre Daily for Six Days in a Week.	Sewage.	Effluent.	Turbidity.	Color.	Free.	Albuminoid.	Nitrates.	Nitrites.		
1901.											
November,	49,500	48	52	V. slight.	0.51	1.6050	.0250	0.38	.0185	4,200	– –
December,	49,500	51	50	Slight.	0.51	2.9100	.0430	2.75	.0092	300	Dec. 16, 1 : 2,000
1902.											
January,	47,700	52	52	V. slight.	–	2.0613	.0275	0.77	.0123	2,492	– –
February,	49,600	52	52	V. slight.	–	1.2825	.0260	2.35	.0210	245	Feb. 24, 1 : 1,500
March,	34,300	47	56	V. slight.	–	0.3050	.0110	2.49	.0150	124	Mar. 31, 1 : 1,000
April,	49,600	51	56	V. slight.	–	0.1280	.0160	2.14	.0075	146	Apr. 21, 1 : 750
May,	45,900	58	66	V. slight.	–	0.1892	.0152	2.20	.0084	228	May 12, 1 : 500
June,	49,500	65	70	Slight.	0.60	1.8900	.0700	0.65	.0405	3,978	June 2, 1 : 250 June 24, 1 : 150
July,	49,600	68	73	V. slight.	0.37	2.2960	.0910	0.06	.0373	4,317	– –
August,	47,800	69	72	Slight.	0.50	1.4400	.0600	0.02	.0010	6,700	– –
September,	38,100	65	65	Slight.	0.61	1.5667	.0760	0.05	.0049	11,600	Sept. 16, 1 : 250
October,	38,600	55	58	Decided.	2.38	3.6975	.1460	0.98	.0455	11,700	– –
November,	49,500	49	61	Slight.	1.58	1.2050	.0560	0.87	.0368	5,550	Nov. 21, 1 : 500
December,	47,700	50	61	Slight.	2.05	2.5600	.0860	2.41	.0400	2,725	– –
1903.											
January,	49,560	45	66	V. slight.	1.04	0.5934	.0416	1.99	.0080	1,340	Jan. 7, 1 : 350
February,	50,000	47	67	Slight.	1.01	0.3470	.0265	1.96	.0048	1,500	Feb. 24, 1 : 250
March,	47,600	48	65	Slight.	3.46	0.5575	.0615	0.76	.0015	63,300	– –

FILTRATION OF WATER.

During 1901–1902 five water filters were in operation at the station receiving Merrimack River water; one of these filters, No. 3B, for a short time only, but the remaining filters throughout the entire period. The filters were constructed of the same grade of sand but were of different depths, and were used largely in comparative work to learn the efficiency of each in removing the total number of bacteria and *B. coli* in the river water when operating at approximately equal rates. The rates of filtration were varied from time to time, and tests for *B. coli* were made in both 1 and 100 cubic centimeters of the effluent from each filter. Bacterial and chemical examinations of samples of the effluent of the Lawrence city filter, collected from different points on the supply system, and of river and canal water were also made. During the larger part of the past four years the turbidity of the river water has been observed daily, and tables are presented showing this turbidity and also its effect upon the length of the period of operation of the experimental filters between scrapings. These tables give the number of days of each period, the rate of filtration of each filter, the total volume of water filtered, presented in terms of gallons per acre of filter surface, and the average turbidity of the river water during each period.

One of the filters, No. 172, operated during 1901 and 1902, contained approximately 13 feet in depth of sand, and figures are presented in this report showing the efficiency of this filter at different depths, as well as tables comparing its efficiency with that of much shallower filters. The filters, the results from which are summarized in this report, are as follows: —

Filter No. 8A, $\frac{1}{200}$ of an acre in area, first put in operation during 1893, contained during 1901 27 inches in depth of sand of an effective size of 0.23 millimeter, and during 1902 approximately 20 inches in depth of sand.

Filters Nos. 142 and 143 are each $\frac{1}{10000}$ of an acre in area, and were first put in operation in June, 1900. Each filter was constructed of sand of an effective size of 0.23 millimeter, and when started Filter No. 142 contained 2 feet in depth of sand and Filter No. 143 5 feet in depth of sand. During 1901 the average depth of sand in Filter No. 142 was 18 inches, and during 1902, 14 inches. The average depth of sand in Filter No. 143 during 1901 was 55 inches and during 1902, 50 inches.

The average analyses of the effluents of all these filters for 1900 has been presented in the report for that year.

The following tables present the analyses of the applied water and effluents of these filters during 1901 and 1902: —

Average Analyses of River Water and Effluents of Filters Nos. 8A, 142, 143 and 172. 1901.

Canal Water (Merrimack River).

[Parts per 100,000.]

RATE. GALLONS PER ACRE DAILY.	Color.	AMMONIA.		Chlorine.	NITROGEN AS		Oxygen Consumed.	Dissolved Oxygen (Per Cent. of Saturation).	Bacteria per Cubic Centimeter.
		Free.	Albuminoid.		Nitrates.	Nitrites.			
–	.46	.0096	.0198	.24	.017	.0002	.51	79.2	5,971

Filter No. 8A.

3.0	.26	.0020	.0089	.24	.030	.0000	.33	42.5	17

Filter No. 142.

3.5	.34	.0059	.0117	.24	.026	.0007	.41	41.5	75

Filter No. 143.

3.4	.33	.0044	.0114	.24	.027	.0002	.38	47.3	16

Filter No. 172.

1.8	.13	.0016	.0057	.22	.022	.0003	.16	14.5	223

Average Analyses of River Water and Effluents of Filters Nos. 8A, 142, 143 and 172. 1902.

Canal Water (Merrimack River).

–	.46	.0062	.0167	.239	.013	.0002	.51	84.5	–

Filter No. 8A.

4.2	.38	.0015	.0103	.241	.020	.0000	.43	51.3	–

Filter No. 142.

4.3	.38	.0020	.0112	.241	.021	.0000	.44	57.8	–

Filter No. 143.

4.3	.36	.0014	.0096	.240	.022	.0000	.41	63.6	–

Filter No. 172.

3.7	.31	.0009	.0072	.239	.022	.0000	.31	51.4	–

COMPARATIVE BACTERIAL AND B. COLI EFFICIENCY OF FILTERS NOS. 142, 143 AND 172.

For the past three years studies of the bacterial and *B. coli* efficiency of these three filters, constructed of different depths of sand of the same grade, have been made. The rates of operation of each filter during different portions of this period have varied from 1,000,000 gallons to 5,000,000 gallons per acre daily, all three filters being operated as nearly as possible at equal rates. In each instance the filters were operated when first started at the lower rate, but the figures of efficiency at this rate given in the table are somewhat misleading when compared with the efficiencies at higher rates, as the filters were then new and had not attained their normal condition.

The following table shows the results during different periods. It will be seen from this table that the deepest filter, No. 172, containing during 1902 twelve or thirteen times as great a depth of sand as the shallower filter, was by far the most efficient in regard to the removal of *B. coli* at each rate tried, and most efficient at the two lower rates in regard to the removal of all bacteria. During the period when operated at the highest rate its apparent bacterial efficiency fell below that of the shallower filters, but this was not due to the passage of bacteria through the filter, but to the increase of one species in the lower layers of sand in the filter. Similar results in regard to growths in the lower layers of filters have been noted in earlier reports of the Board.

The figures in the table show that Filter No. 142, containing from Sept. 19, 1900, to June 30, 1901, only about 21 inches in depth of sand, gave as good average results when operating at a rate of 2,500,000 gallons per acre daily as Filter No. 143, containing during this period 57.5 inches in depth of sand and operating at the same rate. With an increase in rate and a decrease in depth of sand in each filter, and when operating at a rate of 5,000,000 gallons per acre daily from July 1, 1901, to Dec. 23, 1902, the deeper filter gave much the best bacterial and *B. coli* efficiency. The effluent of the shallower filter during this period of eighteen months containing six times as many bacteria as the effluent of the deeper filter and *B. coli* were found in 16 per cent. of the samples as against 6 per cent. of the samples of the effluent of Filter No. 143.

Table showing the Relative Efficiency of Shallow and Deep Filters when operated at Equal Rates.

Filter.	Period.	Number of Days of Period.	Quantity of Water passed (Million Gallons per Acre).			Average Depth of Sand (Inches).	Times Filter was scraped.	Average Number of Bacteria Per Cubic Centimeter.	Per Cent. of Bacteria removed.	Number of Samples tested for *B. Coli.*	Times *B. Coli* was found.	Per Cent. of Samples containing *B. Coli.*
				Daily.								
			Total.	Rate Intended.	Actual Rate.							
142, . .	June 12, 1900, Sept. 18, 1900,	95	94	1.0	0.99	23.5	3	581	83.4	73	8	10
	Sept. 19, 1900, June 30, 1901,	262	603	2.5	2.31	21.0	11	34	99.0	150	16	10
	July 1, 1901, Dec. 23, 1902,	432	1,897	5.0	4.40	12.8	40	248	97.2	256	41	16
143, . .	June 12, 1900, Sept. 18, 1900,	95	96	1.0	1.02	59.5	2	524	85.1	73	8	10
	Sept. 19, 1900, June 30, 1901,	264	635	2.5	2.31	57.5	6	45	98.8	152	15	10
	July 1, 1901, Dec. 23, 1902,	442	1,912	5.0	4.32	50.5	26	41	98.9	254	16	6
172, . .	May 25, 1901, June 30, 1901,	34	35	1.0	1.03	165.0	0	180	93.8	28	0	0
	July 1, 1901, May 14, 1902,	120	277	2.5	2.31	165.0	0	13	99.6	91	3	3
	May 15, 1902, Nov. 30, 1902,	158	648	5.0	4.10	163.5	7	391	95.6	136	9	7

BACTERIA AND B. COLI IN SAMPLES FROM DIFFERENT DEPTHS OF FILTER No. 172.

During 1901 samples were collected from different depths of Filter No. 172, containing at that time 13 feet in depth of sand and operating at a rate of 2,500,000 gallons per acre daily. These samples were collected from petcocks upon the side of the filter, from which pipes extended into the filter. Samples were collected daily from July 22 to September 7, inclusive, at depths of 55 inches, 110 inches and 156 inches. The average number of bacteria at these depths was 12, 7 and 6 per cubic centimeter, respectively. Four of the samples collected at a depth of 55 inches gave positive tests for *B. coli*, none of those collected at the depth of 110 inches, and 1 collected at the depth of 156 inches.

EFFECT OF SCRAPING FILTERS OF DIFFERENT DEPTHS UPON BACTERIAL AND B. COLI EFFICIENCY.

A large amount of data has been gathered during the past three years in regard to the efficiency of shallow and deep filters before and after scraping, and this is presented in following tables. These tables give the average bacterial and *B. coli* efficiency of filters Nos. 142, 143 and 172 for periods of seven days before and seven days after scraping. Filter No. 142, at the beginning of the period reviewed (July, 1900), contained 24 inches in depth of sand, Filter No. 143, 60 inches in depth, and Filter No. 172, 165 inches in depth. At the end of the period the depths were as follows: Filter No. 142, 12 inches, Filter No. 143, 50 inches, and Filter No. 172, 163 inches.

An examination of the tables shows that filters Nos. 142 and 143 each gave very similar results during the first six months of this three-year period, the shallow filter being as efficient as the deeper one. During 1901, Filter No. 143, the deeper filter, gave much better bacterial efficiency, both just before and just after scraping. The depths at this time averaged 21 and 57 inches, respectively. During 1902 this difference was still more marked, the bacterial efficiency of Filter No. 143 never falling below 98 per cent. during these periods, while an efficiency below 90 per cent. was often given by Filter No. 142. The approximate depth of each filter during this period was 13 and 51 inches, respectively. During 1902, Filter No. 172, 165 inches in depth, apparently gave low bacterial efficiency, but the bacteria found in its effluent were growths in the filter, and not bacteria that had passed through the filter. The *B. coli* efficiency of this filter was excellent.

Table showing Effect of Scraping on Bacterial and B. Coli Results.

Filter No. 142.

PERIOD OF SEVEN DAYS PRECEDING SCRAPING.						PERIOD OF SEVEN DAYS FOLLOWING SCRAPING.			
Rate. Million Gallons per Acre Daily.	Date scraped.	Average Number of Bacteria per Cubic Centimeter.	Per Cent. removed.	Times *B. Coli* was found.	Per Cent. of Samples containing *B. Coli.*	Average Number of Bacteria per Cubic Centimeter.	Per Cent. removed.	Times *B. Coli* was found.	Per Cent. of Samples containing *B Coli.*
	1900.								
1.0	July 26	2,600	59.4	0	0	569	87.1	0	0
1.0	Aug. 21	123	96.3	1	17	292	94.5	0	0
2.5	Oct. 1	19	99.6	0	0	36	99.4	0	0
2.5	Oct. 16	32	99.7	0	0	64	99.0	0	0
2.5	Nov. 6	59	98.8	0	0	31	99.6	0	0
2.5	Nov. 23	19	99.7	1	17	78	98.5	4	80
2.5	Dec. 18	295	91.7	2	33	124	98.1	2	40

Table showing Effect of Scraping on Bacterial and B. Coli Results — Concluded.

Filter No. 142 — Concluded.

PERIOD OF SEVEN DAYS PRECEDING SCRAPING.						PERIOD OF SEVEN DAYS FOLLOWING SCRAPING.			
Rate. Million Gallons per Acre Daily.	Date scraped.	Average Number of Bacteria per Cubic Centimeter.	Per Cent. removed.	Times *B. Coli* was found.	Per Cent. of Samples containing *B. Coli.*	Average Number of Bacteria per Cubic Centimeter.	Per Cent. removed.	Times *B. Coli* was found.	Per Cent. of Samples containing *B. Coli.*
	1901.								
2.5	Jan. 5	33	98.4	0	0	62	98.1	0	0
2.5	Jan. 26	16	99.0	–	–	64	97.3	–	–
2.5	Feb. 14	47	98.9	–	–	23	98.9	–	–
2.5	Mar. 8	55	98.9	–	–	52	98.9	–	–
2.5	Apr. 3	27	98.2	–	–	34	97.7	–	–
5.0	July 5	14	99.5	0	0	15	99.2	1	20
5.0	July 12	15	99.1	1	20	12	99.5	0	0
5.0	July 23	9	99.4	0	0	16	98.2	1	17
5.0	Aug. 7	16	99.6	0	0	54	98.8	0	0
5.0	Aug. 16	29	99.3	0	0	104	98.5	1	17
5.0	Sept. 3	20	99.1	0	0	17	99.2	1	17
5.0	Sept. 17	20	99.7	0	0	49	98.9	0	0
5.0	Oct. 2	50	99.1	0	0	49	99.9	0	0
5.0	Oct. 17	42	99.8	0	0	26	98.8	0	0
5.0	Nov. 1	4	96.0	0	0	18	98.2	0	0
5.0	Nov. 15	11	98.2	0	0	141	92.7	0	0
5.0	Nov. 27	133	88.9	0	0	37	87.7	0	0
5.0	Dec. 7	37	87.7	0	0	12	98.9	0	0
5.0	Dec. 14	12	98.9	0	0	36	98.7	0	0
	1902.								
5.0	Jan. 16	29	98.8	–	–	289	93.6	–	–
5.0	Feb 3	254	94.8	–	–	115	97.9	–	–
5.0	Apr. 24	153	92.7	0	0	21	99.6	0	0
5.0	May 14	30	98.7	0	0	67	98.8	0	0
5.0	May 28	48	98.8	1	17	29	99.2	2	40
5.0	June 30	188	98.5	2	33	181	99.0	1	25
5.0	July 15	33	99.8	1	17	22	99.7	0	0
5.0	July 25	19	99.9	0	0	60	99.9	0	0
5.0	Aug. 2	60	99.9	0	0	21	99.4	0	0
5.0	Aug. 9	21	99.4	0	0	126	99.1	1	17
5.0	Aug. 19	121	99.1	1	17	852	97.7	1	20
5.0	Sept. 2	139	98.6	0	0	99	98.7	1	17
5.0	Sept. 12	35	99.6	2	33	105	99.2	1	17
5.0	Oct. 22	211	96.4	0	0	842	89.6	3	50
5.0	Nov. 12.	1,070	84.7	0	0	468	88.3	2	33
0	Nov. 25	75	97.1	3	60	317	95.6	3	75
5.0	Dec. 1	194	94.5	2	50	646	94.1	1	17
5.0	Dec. 9	646	94.1	1	17	494	94.0	4	80

Table showing Effect of Scraping on Bacterial and B. Coli Results.

Filter No. 143.

PERIOD OF SEVEN DAYS PRECEDING SCRAPING.						PERIOD OF SEVEN DAYS FOLLOWING SCRAPING.			
Rate. Million Gallons per Acre Daily.	Date scraped.	Average Number of Bacteria per Cubic Centimeter.	Per Cent. removed.	Times *B. Coli* was found.	Per Cent. of Samples containing *B. Coli.*	Average Number of Bacteria per Cubic Centimeter.	Per Cent. removed.	Times *B. Coli* was found.	Per Cent. of Samples containing *B. Coli.*
	1900.								
1.0	Aug. 31,	927	74.2	0	0	568	68.3	2	40
2.5	Oct. 20,	71	99.1	0	0	29	99.2	0	0
2.5	Nov. 23,	52	99.2	2	33	99	98.1	2	50
	1901.								
2.5	Jan. 1,	25	99.1	0	0	82	96.7	1	17
2.5	Feb. 18,	67	98.3	-	-	47	98.0	-	-
2.5	April 6,	28	98.1	-	-	59	98.7	-	-
5.0	July 23,	17	98.9	0	0	12	98.6	2	33
5.0	Oct. 17,	16	99.9	0	0	41	98.1	0	0
5.0	Nov. 1,	5	99.8	0	0	4	99.6	0	0
5.0	Nov. 19,	2	99.7	0	0	81	94.6	0	0
5.0	Dec. 14,	11	99.0	0	0	22	99.2	0	0
	1902.								
5.0	Jan. 3,	25	99.7	-	-	43	98.8	-	-
5.0	Jan. 16,	43	98.8	0	0	33	99.3	0	0
5.0	May 23,	16	99.7	0	0	15	99.7	0	0
5.0	June 30,	27	99.8	1	17	26	99.9	1	25
5.0	July 30,	72	99.9	0	0	32	99.8	0	0
5.0	Aug. 21,	11	99.9	0	0	50	99.8	1	17
5.0	Sept. 9,	11	99.9	2	33	19	99.8	1	17
5.0	Oct. 29,	14	99.8	0	0	100	99.6	3	33
5.0	Nov. 14,	17	99.7	0	0	61	98.3	1	17
5.0	Nov. 26,	12	99.3	0	0	52	98.6	2	40
5.0	Dec. 4,	52	98.6	2	40	57	99.6	1	20
5.0	Dec. 11,	50	99.6	1	17	143	98.1	0	0

Filter No. 172.

	1902.								
5.0	June 10,	34	99.6	0	0	16	99.9	0	0
5.0	July 23,	800	88.4	0	0	398	99.2	0	0
5.0	Aug. 27,	2,313	93.7	0	0	246	96.0	0	0
5.0	Sept. 3,	246	95.0	0	0	313	97.0	0	0
5.0	Sept. 18,	798	93.8	2	33	357	98.3	0	0
5.0	Oct. 28,	38	99.5	0	0	97	98.7	1	17
5.0	Nov. 19,	21	99.5	0	0	29	98.6	1	17

TURBIDITY OF MERRIMACK RIVER WATER.*

For several years determinations of the turbidity of the river water by the platinum wire method have been made. These turbidity observations have, during portions of the period shown in the following tables, been made in the river opposite the experiment station and below the city, and during portions of the period in the canal, as it is the river water that comes to the station through the Essex Company's canal that passes to the experimental filters. The water in this canal is taken from the river above the city.

River readings have been generally slightly higher than the canal readings, but all readings are included in the averages.

The first table following gives the average turbidity by months of all readings from Jan. 1, 1899, to Dec. 31, 1902, inclusive; a second table gives series of daily observations during months of maximum and minimum turbidity of the river, and a third table, during months of maximum and minimum flow.

These records are not as complete as could be wished, owing to the fact that on several occasions the readings have been omitted for a number of days at a time owing to various reasons, and at times these omissions have been made when the turbidities have been high.

Monthly Averages of Turbidity of the Merrimack River at Lawrence.

MONTH.	1899.	1900.	1901.	1902.
January,	.0532	.1092	.0500	.0714
February,	.0428	.1042	.0435	.0400
March,	.0492	.0661	.0625	–
April,	.0539	.0884	.0476	.0476
May,	.0647	.0489	.0435	.0455
June,	.0826	.0764	.0357	.0417
July,	.0794	.0955	.0370	.0400
August,	.0831	.0843	.0357	.0385
September,	.0827	.0517	.0357	.0385
October,	.0978	.0360	.0417	.0455
November,	.1045	.0556	.0476	.0385
December,	.1122	.0472	.0588	.0417
Average,	.0755	.0720	.0466	.0454

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* Turbidity determined by reading the number of inches below the surface of the water that a platinum wire, 1 millimeter in diameter, can be seen and recording the reciprocal of this number.

Daily Turbidity of Merrimack River at Lawrence during Months of Maximum and Minimum Average Turbidity.

Day of the Month.	1899.		1900.		1901.		1902.	
	Maximum. December.	Minimum. March.	Maximum. January.	Minimum. December.	Maximum. March.	Minimum. August.	Maximum. January.	Minimum. September.
1,	.0641	.0490	–	.0385	.0476	.0370	.0769	.0370
2,	.1042	.0490	–	–	.0500	.0294	.0455	–
3,	–	–	–	.0345	–	.0294	.0455	–
4,	.0463	.0556	–	–	.0476	–	.0455	–
5,	.1042	–	.1042	.0769	.0500	.0286	–	.0556
6,	.1042	.0556	.1190	.0714	.0526	.0370	–	.0526
7,	.1677	–	–	.0625	.0526	.0400	–	–
8,	.1677	.0556	.0694	–	.0556	.0400	.0625	.0417
9,	.1389	.0490	.1042	–	.0526	.0385	.0625	–
10,	–	.0417	.1190	.0476	–	.0476	.0714	.0476
11,	.0521	.0521	.1389	.0500	–	–	–	.0500
12,	.1042	–	.1190	.0556	.0833	.0385	–	.0476
13,	.0833	.0490	.1667	.0417	.0909	.0333	.0455	.0476
14,	.1667	.0521	–	.0476	.0909	.0400	.0526	–
15,	.1667	.0556	.0833	.0476	.0714	.0400	.0455	–
16,	.1667	.0490	.1190	–	.0588	.0455	–	.0323
17,	–	.0463	.1389	.0455	–	.0476	–	.0323
18,	.0694	.0521	.0926	.0455	–	–	.0417	.0370
19,	.1667	–	.1190	.0400	.0476	.0313	–	–
20,	.1667	.0439	.1389	–	.0526	.0303	–	.0323
21,	.1667	.0521	–	.0455	–	.0313	–	–
22,	.1190	.0490	.1042	.0417	.0667	.0323	–	.0357
23,	.1389	–	.0926	.0526	.1000	.0313	.0435	.0313
24,	.0694	.0556	.1190	.0385	–	.0323	.0833	–
25,	–	.0463	.0926	–	.0625	–	.0769	.0333
26,	.1042	–	.0833	.0417	.0588	–	–	.0313
27,	.1042	.0439	.0926	.0385	.0909	.0357	.0625	–
28,	–	.0521	–	–	.0909	.0333	.0556	–
29,	–	.0439	.0833	.0370	.0769	–	–	.0333
30,	–	.0417	.0926	–	.0833	.0370	–	–
31,	–	.0417	.1190	.0370	–	.0303	.0385	–
Average,	.1122	.0492	.1092	.0472	.0625	.0357	.0714	.0385

Daily Turbidity of Merrimack River at Lawrence during Months of Maximum and Minimum Flow.

Day of the Month.	1899.		1900.		1901.	
	Maximum. April.	Minimum October.	Maximum. February.	Minimum. July.	Maximum. April.	Minimum. February.
1,	.0417	-	.1042	.1000	.0476	.0476
2,	-	.0556	.1042	.1000	.0345	.0714
3,	.0333	.0694	.1042	.1111	.0769	-
4,	.0298	.0833	-	-	.0588	.0714
5,	.0333	.0926	.1667	.1429	.0667	-
6,	.0362	.1190	.1190	.1250	.1000	.0417
7,	.0362	.0833	.1042	.1250	-	.0400
8,	.0417	.0490	.0926	-	-	.0476
9,	-	.0926	.0926	.1000	-	-
10,	.0556	.1042	.1389	.0769	-	-
11,	.0417	.1190	-	.1111	-	-
12,	.0417	.1389	.0833	.1111	-	.0476
13,	.0521	.1667	.1389	.0909	-	.0769
14,	.0417	-	-	.0769	-	.0400
15,	.0490	.0521	-	-	-	.0556
16,	-	.0833	-	.1111	-	.0526
17,	0833	.1667	-	.0833	.0476	-
18,	.0694	.1190	-	.0769	.0400	.0400
19,	-	.0694	-	.0833	.0294	.0345
20,	.0641	.0641	.0694	.0909	.0385	.0385
21,	.0595	-	.0833	.0909	-	.0417
22,	.0521	.0926	.1389	-	.0455	.0400
23,	-	.0926	.1042	.0833	.0385	.0417
24,	.0694	.1667	.0641	.0833	.0833	-
25,	.0595	.1667	-	.0833	.1250	.0385
26,	.0833	.1667	.1042	.0769	.0588	-
27,	.0758	.0833	.0833	.0833	.0500	.0400
28,	.0833	-	.0833	.0909	-	-
29,	.0594	.0521	-	-	.0345	-
30,	-	.0926	-	.0909	.0345	-
31,	-	-	-	.0833	-	-
Average,	.0539	.0978	.1042	.0955	.0476	.0435

The Effect of the Varying Turbidity of River Water upon the Period of Operation of Filters between Scrapings.

A study has been made of the experimental filters to learn whether or no the varying turbidity of the river water has any particular influence upon the length of the period of operation of these filters between scrapings. These studies have shown that the river generally has so low a turbidity that the slight variations have little influence in determining the length of this period; other factors, such as amount of organic matter in the water, slight variations in the depth of sand removed at times of scraping, etc., having a much greater influence. For example, the following table shows the relation between average turbidity and the period of operation of Filter No. 143 between scrapings during the past two and one-half years, Filter No. 143 containing at the beginning of the period 5 feet in depth of sand, with an effective size of 0.23 millimeter, and at the end of 1902 about 4 feet in depth. The rates of operation are given in the table.

Filter No. 143.

Period.	Length of Period — Days.	Quantity of Water passed. Million Gallons per Acre.			Average Turbidity of River Water.
		Total.	Daily.		
			Intended Rate.	Actual Rate.	
June 19 to Aug. 31, 1900,	61	73	1.0	1.19	.083
Sept. 1 to Oct. 20, 1900,	50	92	2.3	1.85	.040
Oct. 21 to Nov. 23, 1900,	33	75	2.5	2.26	.042
Nov. 24 to Jan. 1, 1901,	37	88	2.5	2.32	.045
Jan. 2 to Feb. 18, 1901,	48	115	2.5	2.19	.048
Feb. 19 to April 6, 1901,	46	116	2.5	2.31	.055
April 7 to April 16, 1901,	1	2	2.5	1.94	-
April 17 to July 23, 1901,	87	245	3.0	2.72	.040
July 24 to Oct. 1, 1901,	62	278	5.0	4.50	.036
Oct. 2 to Oct. 17, 1901,	13	52	5.0	4.00	.040
Oct. 18 to Nov. 1, 1901,	13	52	5.0	3.99	.043
Nov. 2 to Nov. 19, 1901,	15	59	5.0	3.92	.043
Nov. 20 to Dec. 3, 1901,	12	46	5.0	3.86	.053
Dec. 4 to Dec. 14, 1901,	10	48	5.0	4.76	.053
Dec. 15 to Dec. 19, 1901,	4	19	5.0	4.65	.143
Dec. 20 to Dec 26, 1901,	6	28	5.0	4.70	.059
Dec. 27 to Jan. 3, 1902,	7	31	5.0	4.47	.053
Jan. 4 to Jan. 16, 1902,	12	58	5.0	4.81	.053
Jan. 17 to Jan. 31, 1902,	14	69	5.0	4.95	.053
Feb. 1 to Feb. 24, 1902,	22	110	5.0	5.00	.042
Feb. 25 to March 7, 1902,	4	20	5.0	4.98	.043
March 8 to April 4, 1902,	17	73	5.0	4.30	.067
April 5 to May 23, 1902,	40	177	5.0	4.42	.043
May 24 to June 30, 1902,	31	128	5.0	4.13	.042
July 1 to July 30, 1902,	24	104	5.0	4.34	.042
July 31 to Aug. 21, 1902,	17	74	5.0	4.34	.037
Aug. 22 to Sept. 9, 1902,	15	62	5.0	4.16	.042
Sept. 10 to Oct. 2, 1902,	12	45	5.0	3.75	.037
Oct. 3 to Oct. 29, 1902,	23	96	5.0	4.15	.045
Oct. 30 to Nov. 14, 1902,	14	58	5.0	4.18	.038
Nov. 15 to Nov. 26, 1902,	10	40	5.0	3.98	.038
Nov. 27 to Dec. 4, 1902,	8	37	5.0	4.70	.042
Dec. 5 to Dec. 11, 1902,	6	24	5.0	4.06	.043

Lawrence City Filter.

The Lawrence city filter is 2.5 acres in area and was constructed during 1893. Each year since its operation tables showing the average analyses of the Merrimack River water applied to this filter, and of the filtered water at different points upon the supply system, have been given in these reports. The following tables give the results of chemical analyses during 1902, and bacterial results are given on subsequent pages in tables presenting bacterial and *B. coli* efficiency: —

Merrimack River Water as it flows upon the Lawrence City Filter.

[Parts per 100,000.]

1902.	Temperature. Deg. F.	Color.	Ammonia.			Chlorine.	Nitrogen as		Oxygen Consumed.
			Free.	Albuminoid.			Nitrates.	Nitrites.	
				Total.	Soluble.				
January,	33	.44	.0057	.0209	.0180	.26	.019	.0000	.53
February,	34	.38	.0073	.0191	.0149	.29	.018	.0001	.52
March,	39	.41	.0028	.0184	.0162	.17	.012	.0000	.45
April,	48	.37	.0036	.0196	.0166	.18	.012	.0000	.43
May,	54	.50	.0038	.0186	.0156	.22	.012	.0000	.45
June,	67	.47	.0087	.0198	.0161	.22	.010	.0001	.50
July,	68	.42	.0158	.0184	.0156	.24	.009	.0002	.46
August,	68	.57	.0124	.0240	.0202	.30	.011	.0004	.69
September,	68	.46	.0152	.0250	.0206	.34	.011	.0003	.56
October,	58	.62	.0110	.0204	.0167	.26	.010	.0001	.70
November,	44	.58	.0044	.0198	.0182	.23	.010	.0000	.66
December,	35	.42	.0069	.0157	.0139	.23	.016	.0000	.52
Average,	50	.47	.0081	.0200	.0169	.24	.013	.0001	.54

Effluent of the Lawrence City Filter.

January,	35	.56	.0108	.0109	.0088	.27	.039	.0000	.41
February,	36	.51	.0124	.0085	.0080	.30	.038	.0000	.34
March,	41	.44	.0097	.0083	.0079	.17	.031	.0000	.31
April,	49	.43	.0097	.0097	.0085	.19	.032	.0000	.29
May,	56	.52	.0046	.0124	.0098	.24	.025	.0002	.32
June,	66	.38	.0076	.0090	.0078	.25	.019	.0001	.38
July,	72	.40	.0074	.0078	.0078	.30	.006	.0000	.34
August,	68	.52	.0074	.0104	.0094	.32	.035	.0000	.43
September,	67	.48	.0126	.0089	.0088	.32	.014	.0001	.34
October,	58	.54	.0070	.0084	.0080	.28	.029	.0000	.46
November,	45	.54	.0088	.0097	.0085	.24	.024	.0000	.52
December,	39	.53	.0107	.0095	.0091	.27	.038	.0000	.40
Average,	53	.49	.0091	.0095	.0085	.26	.028	.0000	.38

Water from the Outlet of the Distributing Reservoir.

[Parts per 100,000.]

1902.	Temperature. Deg. F.	Color.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Soluble.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.
January,	35	.48	.0082	.0106	.0095	.27	.040	.0000	.39
February,	35	.44	.0084	.0097	.0085	.29	.037	.0000	.32
March,	40	.42	.0084	.0081	.0079	.17	.030	.0000	.28
April,	48	.35	.0053	.0100	.0088	.19	.030	.0000	.30
May,	56	.44	.0018	.0096	.0086	.22	.042	.0000	.30
June,	65	.35	.0016	.0085	.0078	.26	.036	.0001	.29
July,	71	.26	.0026	.0078	.0078	.30	.036	.0004	.26
August,	68	.36	.0046	.0082	.0072	.30	.037	.0004	.25
September,	68	.40	.0025	.0081	.0081	.30	.033	.0001	.31
October,	59	.39	.0023	.0088	.0077	.30	.031	.0000	.37
November,	47	.56	.0042	.0110	.0105	.26	.028	.0000	.44
December,	38	.41	.0069	.0103	.0095	.27	.034	.0000	.30
Average,	53	.41	.0047	.0092	.0085	.26	.035	.0001	.32

Water from a Tap at Lawrence City Hall.

[Parts per 100,000.]

1902.	Temperature. Deg. F.	Color.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.
January,	37	.51	.0076	.0104	.27	.040	.0000	.38
February,	37	.43	.0075	.0089	.28	.025	.0000	.31
March,	40	.43	.0078	.0089	.17	.030	.0000	.27
April,	48	.36	.0044	.0101	.20	.030	.0000	.28
May,	56	.41	.0014	.0090	.22	.042	.0000	.27
June,	63	.38	.0014	.0095	.24	.036	.0001	.29
July,	70	.38	.0008	.0074	.30	.039	.0000	.24
August,	66	.33	.0012	.0086	.30	.040	.0000	.23
September,	67	.40	.0015	.0090	.30	.032	.0000	.31
October,	63	.45	.0008	.0091	.29	.035	.0000	.36
November,	51	.55	.0025	.0104	.26	.029	.0000	.42
December,	40	.40	.0046	.0101	.28	.034	.0000	.34
Average,	53	.42	.0035	.0093	.26	.034	.0000	.31

Water from a Tap at Lawrence Experiment Station.

[Parts per 100,000.]

1902.	Temperature. Deg. F.	Color.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.
			Free.	Albuminoid.		Nitrates.	Nitrites.	
January,	44	.43	.0033	.0095	.27	.045	.0000	.35
February,	43	.43	.0029	.0086	.28	.036	.0000	.29
March,	43	.39	.0021	.0069	.17	.035	.0000	.26
April,	48	.35	.0014	.0080	.19	.031	.0000	.27
May,	51	.38	.0026	.0096	.23	.039	.0000	.25
June,	58	.26	.0013	.0071	.24	.034	.0000	.25
July,	62	.29	.0006	.0056	.27	.040	.0000	.20
August,	65	.22	.0010	.0062	.30	.037	.0004	.17
September,	67	.34	.0008	.0076	.30	.032	.0000	.33
October,	63	.35	.0007	.0080	.29	.034	.0002	.35
November,	53	.47	.0016	.0098	.27	.032	.0000	.40
December,	46	.38	.0029	.0081	.27	.034	.0000	.31
Average,	54	.36	.0018	.0079	.26	.036	.0001	.29

BACTERIAL EXAMINATIONS AND RESULTS.

Throughout the year 1902, besides the daily determinations of the number of bacteria in the river water at several points and in the effluents of the experimental filters and samples of Lawrence city filter water collected at several points of the supply system, many hundred tests for *B. coli* in unfiltered and filtered water have been made.

The following tables present the results of this bacterial work. These tables show the number of bacteria in the river water and in the effluents of the various filters, the efficiency of these filters figured in percentages of total bacteria removed, the number of *B. coli* in the river and canal water, and the result of tests for *B. coli* in the filter effluents.

In this *B. coli* work tests for the germ in 1 and 100 cubic centimeters of each effluent have been made, and the comparative results are given.

At the end is a table comparing the yearly averages of each filter. It will be noticed that the city filter, operating at the lowest rate, and Filter No. 8A, the largest and oldest experimental filter at the station, gave the best bacterial efficiency, and that the city filter gave the best *B. coli* efficiency. The efficiency of the city filter would undoubtedly have been even more satisfactory except for the disturbance of the sand when constructing dividing walls in August. None of the 23 samples collected from the outlet of the city reservoir during this month, however, showed the presence of

B. coli, either when testing 1 or 100 cubic centimeters, and the total number of bacteria present in these samples was only 75 per cubic centimeter, while the filter effluent, as pumped to the reservoir, contained *B. coli* in 14 per cent. of the one cubic centimeter samples examined and also contained 324 bacteria per cubic centimeter. Filter No. 142, containing only about 1.5 feet in depth of sand during the year, gave, as would be expected, a much poorer bacterial and *B. coli* efficiency than Filter No. 143, containing about 4 feet of the same grade of sand; the bacterial efficiency of these two filters being 96.4 and 99.5, respectively. Twenty-one per cent. of the samples of Filter No. 142 showed *B. coli* when testing 1 cubic centimeter and 32 per cent. when testing 100 cubic centimeters. With Filter No. 143, however, the figures were 8 and 18 per cent., respectively; that is to say, with only a difference of 3 per cent. in total bacterial efficiency the deeper filter gave a *B. coli* efficiency fully twice as good as the shallower filter.

Canal Water (Merrimack River Water applied to Experimental Filters).

[Average of Bacterial Analyses.]

1902.	Average Number of Bacteria per c.c.	Number of Samples tested for B. Coli.	Number of Times B. Coli was found.	Average Number of B. Coli per c.c.	Per Cent. of Samples containing B. Coli.
January,	4,400	5	5	23	100
February,	6,900	3	3	42	100
March,	9,600	1	1	13	100
April,	2,100	1	1	39	100
May,	4,000	25	25	55	100
June,	11,100	24	24	67	100
July,	22,800	24	24	98	100
August,	17,700	20	20	343	100
September,	13,300	19	19	129	100
October,	8,800	23	23	80	100
November,	4,900	23	23	48	100
December,	10,000	26	26	66	100
	9,600	194	194	84	100

Filter No. 8A.

[Average of Bacterial Analyses.]

1902.	Average Number of Bacteria per c.c.	Per Cent removed. (Efficiency)	NUMBER OF SAMPLES TESTED FOR B. COLI.		NUMBER OF TIMES B. COLI WAS FOUND.		PER CENT. OF SAMPLES CONTAINING B. COLI.	
			1 c.c.	100 c.c.	1 c.c.	100 c.c.	1 c.c.	100 c.c.
January,	35	99.2	5	5	1	1	20	20
February,	124	98.2	2	2	1	1	50	50
March,	29	99.7	1	1	0	0	0	0
April,	16	99.2	1	1	0	0	0	0
May,	34	99.1	23	23	0	2	0	9
June,	130	98.8	22	22	0	3	0	14
July,	42	98.8	22	22	0	2	0	9
August,	65	99.6	19	19	0	0	0	0
September,	14	99.9	17	17	0	4	0	24
October,	71	99.2	21	21	0	1	0	5
November,	82	98.3	21	21	1	1	5	5
December,	226	97.7	20	20	6	9	30	45
	72	99.3	174	174	9	24	5	14

Filter No. 142.

[Average of Bacterial Analyses.]

1902.	Average Number of Bacteria per c.c.	Per Cent. removed. (Efficiency.)	Number of Samples tested for B. Coli.		Number of Times B. Coli was found.		Per Cent. of Samples containing B. Coli.	
			1 c.c.	100 c.c.	1 c.c.	100 c.c.	1 c.c.	100 c.c.
January, ...	206	95.2	5	-	1	-	20	-
February, ...	479	93.1	3	-	0	-	0	-
March, ...	82	99.1	1	-	0	-	0	-
April, ...	153	92.7	1	-	0	-	0	-
May, ...	45	98.9	23	23	3	7	13	30
June, ...	120	98.9	23	23	7	14	30	61
July, ...	64	99.7	22	22	2	4	9	18
August, ...	311	98.2	18	18	2	2	11	11
September, ...	81	99.4	17	17	4	8	24	47
October, ...	1,268	85.5	24	24	4	9	17	37
November, ...	688	86.9	23	23	8	4	35	17
December, ...	597	94.0	17	17	6	5	35	29
	341	96.4	177	167	37	53	21	32

Filter No. 143.

1902.	Average Number of Bacteria per c.c.	Per Cent. removed. (Efficiency.)	Number of Samples tested for B. Coli.		Number of Times B. Coli was found.		Per Cent. of Samples containing B. Coli.	
			1 c.c.	100 c.c.	1 c.c.	100 c.c.	1 c.c.	100 c.c.
January, ...	36	99.1	4	-	0	-	0	-
February, ...	86	98.9	3	-	1	-	33	-
March, ...	23	99.8	1	-	0	-	0	-
April, ...	12	99.4	1	-	0	-	0	-
May, ...	16	99.6	23	23	0	1	0	4
June, ...	17	99.8	23	23	1	7	4	30
July, ...	31	99.9	22	22	1	2	5	9
August, ...	27	99.8	17	17	1	1	6	6
September, ...	13	99.9	17	17	3	8	18	47
October, ...	216	97.5	22	22	1	5	5	23
November, ...	38	99.2	22	23	4	3	18	13
December, ...	66	99.3	16	16	2	4	13	25
	49	99.5	171	163	14	31	8	19

Merrimack River Water as it flows upon the Lawrence City Filter.

[Average of Bacterial Analyses.]

1902.	Average Number of Bacteria per c.c.	Number of Samples tested for B. Coli.	Number of Times B. Coli was found.	Average Number of B. Coli per c.c.	Per Cent. of Samples containing B. Coli.
January, ...	7,300	25	25	21	100
February, ...	7,400	23	22	45	96
March, ...	4,500	16	15	20	94
April, ...	4,200	23	22	16	96
May, ...	3,300	3	3	28	100
June, ...	2,700	5	5	55	100
July, ...	37,000	15	15	161	100
August, ...	20,900	23	23	219	100
September, ...	15,300	14	14	104	100
October, ...	10,000	12	12	53	100
November, ...	4,300	12	12	83	100
December, ...	7,000	25	25	72	100
	10,300	196	193	73	99

Effluent of the Lawrence City Filter.

[Average of Bacterial Analyses.]

1902.	Average Number of Bacteria per c.c.	Per Cent. removed. (Efficiency.)	Number of Samples tested for B. Coli.		Number of Times B. Coli was found.		Per Cent. of Samples containing B. Coli.	
			1 c.c.	100 c.c.	1 c.c.	100 c.c.	1 c.c.	100 c.c.
January,	47	99.4	27	27	1	4	4	15
February,	44	99.4	23	23	1	4	4	17
March,	61	98.6	16	16	1	1	6	6
April,	75	98.2	24	24	0	0	0	0
May,	30	99.1	3	3	0	0	0	0
June,	32	98.8	5	5	0	0	0	0
July,	35	99.9	16	16	0	0	0	0
August,	324	98.4	21	21	3	2	14	10*
September,	23	99.8	15	15	0	1	0	7
October,	105	98.9	12	12	0	0	0	0
November,	25	99.3	12	12	0	0	0	0
December,	109	98.4	25	25	2	4	8	16
	76	99.3	199	199	8	16	4	8

* Constructing dividing walls.

Water from the Outlet of the Lawrence Reservoir.

January,	61	99.2	27	27	0	4	0	15
February,	65	99.1	23	23	0	1	0	4
March,	85	98.1	16	16	1	1	6	6
April,	71	98.3	24	24	0	0	0	0
May,	27	99.2	3	3	0	0	0	0
June,	40	98.5	5	5	0	0	0	0
July,	58	99.8	16	16	0	0	0	0
August,	73	99.7	23	23	0	0	0	0
September,	33	99.8	14	14	0	0	0	0
October,	49	99.5	12	12	0	0	0	0
November,	43	99.0	12	12	0	0	0	0
December,	286	95.9	23	23	0	3	0	13
	74	98.8	198	198	1	9	1	5

Water from a Tap at Lawrence City Hall.

[Average of Bacterial Analyses.]

1902.	Average Number of Bacteria per c.c.	Per Cent. removed. (Efficiency.)	Number of Samples tested for B. Coli.		Number of Times B. Coli was found.		Per Cent. of Samples containing B. Coli.	
			1 c.c.	100 c.c.	1 c.c.	100 c.c.	1 c.c.	100 c.c.
January,	58	99.2	27	27	0	4	0	15
February,	51	99.3	23	23	0	1	0	4
March,	64	98.5	15	15	0	0	0	0
April,	66	98.4	24	24	0	0	0	0
May,	26	99.2	3	3	0	0	0	0
June,	40	98.5	5	5	0	0	0	0
July,	57	99.8	16	16	0	0	0	0
August,	112	99.5	20	20	0	0	0	0
September,	66	99.5	14	14	0	0	0	0
October,	125	98.7	12	12	0	0	0	0
November,	103	97.6	12	12	0	0	0	0
December,	96	98.6	24	24	2	3	8	15
	72	98.9	195	195	2	8	1	4

Lawrence City Water from a Tap at the Experiment Station.

January,	49	99.3	27	27	2	4	7	15
February,	45	99.4	23	23	0	0	0	0
March,	51	98.9	16	16	0	1	0	6
April,	49	98.8	24	24	0	0	0	0
May,	24	99.3	26	26	0	0	0	0
June,	24	99.1	23	23	2	2	9	9
July,	35	99.9	26	26	0	0	0	0
August,	61	99.7	23	23	0	0	0	0
September,	89	99.4	25	25	2	4	8	16
October,	65	99.3	26	26	0	0	0	0
November,	48	98.9	24	24	1	1	4	4
December,	67	99.0	25	25	0	4	0	16
	51	99.0	288	288	7	16	2	6

ON THE VALUE OF TESTS FOR BACTERIA OF SPECIFIC TYPES AS AN INDEX OF POLLUTION,

TOGETHER WITH

EXPERIMENTS UPON THE RELATIVE VIABILITY OF B. COLI AND B. TYPHOSUS.

By H. W. CLARK and STEPHEN DEM. GAGE.

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In recent years increased attention has been given by those interested in sanitary problems, and especially water supply and water purification, to methods for the determination of fecal bacteria in water, and to the significance of their presence as a determining factor in judging the degree of purity of a water.

During the past eight years the work at the experiment station along this line has covered a wide field, and has included examinations of over 18,000 samples, including 4,700 samples of polluted river water, 9,100 samples of filtered waters, 2,200 samples of other potable waters, including samples from springs, curb wells, tubular wells, domestic wells, ponds and other surface supplies, etc., and 2,100 miscellaneous samples, including shellfish, sea water, ice, milk, dust, excrement from men and animals, grains, food stuffs, etc. Investigations have also been made upon the seasonal distribution of B. coli, the elimination of B. coli from water by storage, as in reservoirs, and studies upon the similarity between the length of life of B. coli and B. typhosus under a variety of conditions.

The principal types of bacteria used as indices of the pollution of water are the colon type, the sewage streptococcus type, the sporogenes type and occasionally the two so-called paracolon types; that is, the aerogenes, or enteritidis, Gärtner, type, and the chologenes type. The colon type is the most numerous of these in normal sewage, and is, accordingly, considered of the most value as a specific indication of pollution.

A number of investigators have published results seeming to show the presence of bacteria of the colon type in samples from sources apparently removed from pollution, and these results tend to discredit the value of tests for organisms of this type as an indication of sewage pollution. Nevertheless, the colon tests, correctly interpreted, are, undoubtedly a valuable aid in the analyses of certain classes of water where the determination of suspected pollution becomes necessary. That B. coli are widely distributed is not to be disputed when we consider that this organism is found in the fecal discharges of men and the major animals widely used as a dressing for arable soil, and in the intestinal contents of many of the smaller animals, both domestic and wild, and in the evacuations from fowls and some of the migratory birds. Flies and other insects may also act as carriers of these germs, depositing them in places where we would least expect to find them. Examinations of 48 flies at the experiment station resulted in the finding of B. coli in or on nine of these, and bacteria of the strepto type in or on three others. No relation could be traced between the locality where these flies were caught and the finding of the test organism. Flies caught about the filter house at the station where sewage is constantly present frequently failing to show the test organism, while others, obtained from localities removed from sewers, privy vaults, stables or any of the usual sources of contamination, gave positive reactions.

The work of many of the critics of the value of the colon tests is open to the objection that their findings are not supported by sufficient data, or that their cultural methods are inadequate when viewed from our own standpoint. The fact that Klein and Houston[1] found organisms similar to B. coli in commercial food stuffs, and have been supported in their findings by a number of other investigators, has been the basis of an attempt to show that the colon bacillus is merely a member of a larger group of saphrophytes of the so-called lactic acid group. These critics, however, fail to note the fact that Klein and Houston also found in these same samples of cereals bacteria of the sewage streptococcus type and of the B. sporogenes type, both of which types are offered by them as indicating sewage pollution. In other words, if we accept the fact that these observers found B. coli, we must also accept the fact that, as shown by other bacterial tests made by them, the grains which they tested had at some time been exposed to pollution. This is not to be wondered at considering that B. coli is frequently found in the excrement from mice and rats, which overrun grain elevators and grain ships, and also the possible chance of contamination during the processes of harvesting, threshing and milling the grain. At the experiment station a number of samples of grains have been examined for B. coli, all of these samples, however, being carefully collected directly from the fields where they were growing, and in no case has any organism been found which would have been in any way confounded with the colon type, notwithstanding the fact that 25 samples of corn were examined which came from a municipal sewage filtration area to which sewage was being applied daily.

For several years the B. coli work at Lawrence was almost entirely confined to determinations of the numbers of the organism present in the Merrimack River water and in the effluents of the filters receiving this water. In these studies many thousand tests were made and the work of the Lawrence city filter and of the different experimental filters, operated under a variety of conditions and at varying rates, have been observed. Much of this work has been summarized in the reports of the Board since 1896, in the chapters upon "Filtration of Water."

Attention has been drawn in these reports to the lower B. coli efficiency of sand filters in winter than in summer, and to the fact that during a disturbance of the city filter, severe enough to cause numerous cases of typhoid fever in Lawrence, the poor quality of the filtered water was more plainly indicated by the decreased B. coli efficiency of this filter than by decreased bacterial efficiency, *i. e.*, removal of the total number of bacteria in the river water.

The fact that water as polluted as that in the Merrimack River shows occasional coli after filtration has been commented upon, and the statement made that the removal by a filter of all B. coli in a raw water is probably an unnecessary degree of bacterial refinement, when the water to be filtered is as polluted as that flowing in the Merrimack River at Lawrence. The truth of this statement can be shown in a number of ways, but most strongly by the very low typhoid death-rate of Lawrence since the construction of the city filter; in fact, one of the lowest death-rates from this cause of any of the cities of the State, notwithstanding the fact that B. coli are found with more or less frequency in the filtered city water when examining 1 cubic centimeter of this water.

In Table No. 1 are shown the results, by years, of examinations of the water of the Merrimack River from three different locations at Lawrence: 1, the water as it flows upon the city filter; 2, the water from the canal as it flows upon the filters at the experiment station; and 3, the water from the river near the station after it has received a large proportion of the sewage from the city. The results of examinations of the effluents of the Lawrence city filter, operating at a rate of 1,500,000 to 2,500,000 gallons per acre daily, and of experimental Filter No. 8A, operating at rates of 2,500,000 to 5,000,000 gallons per acre, are also shown.

TABLE No. 1.— *Showing the Yearly and Total Averages of the Presence of B. Coli in the Merrimack River and in the Effluents of the Lawrence City Filter and Filter No. 8A.*

Merrimack River at Intake of the Lawrence City Filter.

YEAR.	1 CUBIC CENTIMETER.			100 CUBIC CENTIMETERS.	
	Number of Samples tested for B. Coli.	Average Number of B. Coli per Cubic Centimeter.	Per Cent. of Samples containing B. Coli.	Number of Samples tested for B. Coli.	Per Cent. of Samples containing B. Coli.
1898,	163	49	98.2	-	-
1899,	180	47	99.4	-	-
1900,	199	87	99.5	-	-
1901,	144	40	97.9	-	-
1902,	196	73	99.0	-	-
1903,*	136	53	98.5	-	-
Total,	1,018	58	98.7	-	-

* To July 1, 1903.

Table No. 1.— *Showing the Yearly and Total Averages of the Presence of B. Coli in the Merrimack River and in the Effluents of the Lawrence City Filter and Filter No. 8 A.*— Concluded.

Year.	1 Cubic Centimeter.			100 Cubic Centimeters.	
	Number of Samples tested for B. Coli.	Average Number of B. Coli per Cubic Centimeter.	Per Cent. of Samples containing B Coli.	Number of Samples tested for B. Coli.	Per Cent. of Samples containing B. Coli.
Merrimack River from Essex Company's Canal.					
1898,	288	53	99.7	-	-
1899,	297	40	99.6	-	-
1900,	288	49	100.0	-	-
1901,	213	27	82.9	-	-
1902,	194	84	100.0	-	-
1903,*	148	33	97.3	-	-
Total,	1,428	48	97.9	-	-
Merrimack River at the Experiment Station.					
1898,	-	-	-	-	-
1899,	114	103	100.0	-	-
1900,	62	170	100.0	-	-
1901,	154	68	92.9	-	-
1902,	12	67	100.0	-	-
1903,*	-	-	-	-	-
Total,	342	102	96.8	-	-
Filtered Water from Lawrence City Filter.					
1898,	170	-	18.8	-	-
1899,	189	-	23.3	-	-
1900,	204	-	18.1	139	38.1
1901,	148	-	6.8	137	28.5
1902,	199	-	4.0	199	8.0
1903,*	136	-	3.7	136	14.7
Total,	1,046	-	13.1	611	20.9
Filtered Water from Filter No. 8A.					
1898,	268	-	12.7	-	-
1899,	247	-	14.2	-	-
1900,	275	-	5.1	191	17.3
1901,	170	-	10.0	143	27.9
1902,	174	-	5.0	174	14.0
1903,*	116	-	9.5	116	24.1
Total,	1,250	-	9.6	624	20.0

* To July 1, 1903.

Seasonal Distribution of B. Coli.

The results of tests for B. coli shown in Table No. 1 have been retabulated, showing the relative findings of B. coli during the five winter months ending March 31 and the seven summer months ending October 31. B. coli has been present in practically all the samples of the Merrimack River water from the three stations shown in the tables. In the water at the intake of the Lawrence city filter and in the water as it flows to the filters at the experiment station, higher numbers of B. coli per cubic centimeter have been found during the summer months than during the winter months in four out of six years, and in the same water, after receiving the sewage of the city of Lawrence, the numbers of B. coli have been higher in the summer season in two out of three years. The average number for five and one-half years at both of the first two locations is also higher for the summer season.

A number of factors enter into the seasonal distribution of B. coli in the river water; we may assume that the polluting sewage from the cities on the water-shed of this river is practically a constant during the two seasons, increasing slowly and regularly as the population increases, and the total amount of solid excrement turned into the river in the form of sewage also increases slowly and regularly, but this increase may be neglected in the comparison since it applies equally to both seasons. The volume of sewage from a given population fluctuates, of course, through wide limits, but the amount of solid excrement in the total volume of the sewage is probably increasing very slowly. The first factor, then, assuming that this solid matter is a constant, is the dilution. A study of the weekly flow of the river and of the averages of the weekly analyses for B. coli show us that as the flow of the river increases the numbers of B. coli diminish; in other words, the greater the dilution, the less the numbers of B. coli, and the periods of flood in the Merrimack River, as contrasted with the periods of low water, have almost uniformly occurred during the winter months. Another factor is the temperature. Owing to the low temperature of the water in winter, bacterial life within it is dormant, and the solid particles entering the river in the sewage and settling out before the flow of the river carries them to Lawrence are not decomposed quickly by bacterial action, and enclosed bacteria liberated, as is the case in summer. Moreover, cold is itself inimical to the life of B. coli, as will be shown later. The factor of dilution is, of course, important also in the filtration of this water. The more bacteria of a certain type in the raw water the more often we would expect, other conditions being equal, to find that type present in the effluent from a sand filter to which that water was being applied. To offset the generally lower numbers in the river water in winter on account of dilution and low temperature, however, the high temperature of summer operates strongly as favoring the reduction in numbers of B. coli by the filter during this season. That is, in the winter the water is cold and the biological processes, which are largely responsible for the purification of the water and the death of organisms of the fecal type while passing through the filter, are sluggish, and the efficiency of the filter is less than during the summer season, when all biological processes are active. Samples from ponds and lakes which have been tested regularly for B. coli during the preceding three years show that B. coli is more frequently found in summer than in winter in seven of the eight sources. About three times as many samples have been collected from these supplies, however, in summer as in winter, which would, in a measure, influence the result, and the shores of a number of these lakes are used as pleasure resorts during the summer.

The yearly results of the analyses of the river water are shown in Table No. 2, and the results of the analyses of the filtered waters are shown in Table No. 3. The results of tests in both 1 and 100 cubic centimeters are shown for the filtered waters. The significance of tests in these two volumes will be discussed further on in this paper.

TABLE NO. 2. — *Showing Relative Distribution of B. Coli in Merrimack River during Five Months ending March 31 and Seven Months ending October 31. — 1898 1903 inclusive.*

At Intake of Lawrence City Filter.

YEAR.	WINTER SEASON.			SUMMER SEASON.		
	Number of Samples tested for B. Coli.	Average B. Coli per Cubic Centimeter.	Per Cent. of Samples containing B. Coli.	Number of Samples tested for B. Coli.	Average B. Coli per Cubic Centimeter.	Per Cent. of Samples containing B. Coli.
1898,	63	30	100.0	53	57	98.0
1899,	120	25	97.5	57	35	96.5
1900,	121	76	99.1	80	93	100.0
1901,	107	102	99.0	33	16	100.0
1902,	111	42	96.5	95	91	99.0
1903,	111	50	98.2	62	74	100.0
Total,	633	54	98.2	380	61	98.9
From Essex Company's Canal.						
1898,	73	27	98.5	164	69	100.0
1899,	127	28	97.5	171	41	95.0
1900,	121	49	100.0	168	46	100.0
1901,	111	68	99.1	143	16	90.2
1902,	17	18	100.0	136	116	100.0
1903,	123	36	98.3	74	45	97.3
Total,	572	38	98.8	856	55	96.9
Opposite Experiment Station.						
1899,	-	-	-	64	84	100.0
1900,	87	119	100.0	11	193	100.0
1901,	23	191	100.0	135	32	93.3
1902,	19	30	89.5	3	112	100.0
1903,	-	-	-	-	-	-
Total,	129	113	98.4	213	105	95.7

TABLE NO. 3.— *Showing Relative Distribution of B. Coli in the Effluent from the Lawrence City Filter and in the Effluent from Filter No. 8A during Five Months ending March 31 and Seven Months ending October 31.—1898-1903 inclusive.*

Effluent of Filter No. 8A.

YEAR.	WINTER SEASON.				SUMMER SEASON.			
	1 CUBIC CENTIMETER.		100 CUBIC CENTIMETERS.		1 CUBIC CENTIMETER.		100 CUBIC CENTIMETERS.	
	Number of Samples tested for B. Coli.	Per Cent. Samples containing B. Coli.	Number of Samples tested for B. Coli.	Per Cent. Samples containing B. Coli.	Number of Samples tested for B. Coli.	Per Cent. Samples containing B. Coli.	Number of Samples tested for B. Coli.	Per Cent. Samples containing B. Coli.
1898, . . .	59	18.7	-	-	106	10.0	-	-
1899, . . .	111	16.2	-	-	138	5.1	-	-
1900, . . .	102	23.5	28	68.0	170	1.7	123	4.1
1901, . . .	113	15.0	95	28.2	99	3.0	82	25.3
1902, . . .	16	18.7	16	18.7	125	0.0	125	9.6
1903, . . .	94	13.8	94	19.2	63	8.0	63	32.0
Total, . .	495	17.3	233	28.7	755	4.5	393	14.7
Effluent of Lawrence City Filter.								
1898, . . .	68	10.4	-	-	54	5.6	-	-
1899, . . .	121	4.2	-	-	66	7.6	-	-
1900, . . .	122	25.2	32	78.1	91	16.5	78	25.6
1901, . . .	116	18.1	96	39.5	33	3.0	33	33.2
1902, . . .	114	2.7	114	10.5	96	3.1	96	3.1
1903, . . .	111	4.5	111	8.1	62	3.2	63	8.0
Total, . .	652	17.3	353	23.8	402	7.2	270	14.4

B. COLI IN SPRING WATER.

During an investigation of spring waters upon the market in Massachusetts, made by the Board during 1900, an account of which, with analyses of the waters, was published in the report of the Board for that year,[2] 282 samples from ninety-six sources were examined. Fourteen of these samples, or less than 5 per cent., were found to contain B. coli, these 14 samples being from thirteen different sources. In only one instance was B. coli found to be present in more than one sample from the same source. Of the 14 samples in which the germ was found, 6 were collected from springs by employees of the Board, the remaining 8 being samples taken from original packages of the water as shipped by the spring water people to their consumers or sold upon the market, and the B. coli present in these last samples could very probably be traced to carelessness and uncleanliness in bottling or handling the waters.

Of the 6 samples collected directly from the springs, in which B. coli was found, 1 was from a source which inspection and chemical analysis showed to be unpolluted; 1 was from a source surrounded by cultivated fields, but without buildings in the immediate vicinity (the chlorine in this sample was about normal for the region, however); the other 4 samples were from locations with either buildings, barn-yards, vaults, etc., in the immediate vicinity, and in which the chlorine was above the normal in each case; in other words, in an examination of 282 samples of spring waters, B. coli was found in less than 5 per cent. of the samples, and in most of those samples collected by employees of the Board in which it was present, evidence of probable pollution was shown by inspection of the surroundings as well as by chemical analysis.

Samples from Public Tubular and Curb Wells.

During the past two or three years 170 samples from twenty-five sets of tubular wells and nineteen curb wells, used as sources of public water supply, have been examined for B. coli. Of the 128 samples from tubular wells which have been examined, only 1 has given a positive test for B. coli, and that when testing 100 cubic centimeters of the water. Of the 42 samples from curb wells, 1 has given a positive test for B. coli when testing 1 cubic centimeter, and 3 when testing 100 cubic centimeters. The waters in these wells are, however, as shown by chemical analysis and the health of the people using them, probably of a good and safe quality. In the curb wells, many feet in diameter, there is, perhaps, a chance for accidental contamination by B. coli to which the tubular or driven wells are not subject. In the one instance where a positive test was obtained in a sample of water from a tubular well, this water had been shown to be suspicious by many chemical analyses, and these wells are near one of the most polluted rivers in the State.

Besides the samples from tubular wells, already enumerated, positive tests were given for B. coli in several samples of water from a supply system drawn from tubular wells, this water having become accidentally contaminated by the introduction of polluted surface water at this time, chemical analysis and determination of numbers of bacteria failing to detect this pollution.

Samples from Domestic or Private Wells.

Five hundred and fifteen samples of water from one hundred and eighty-six private or domestic wells have been collected and examined during the past two years. Of these, 14, or 2.7 per cent., have given a positive test for B. coli when taking 1 cubic centimeter, and 17, or 3.3 per cent., when taking 100 cubic centimeters of the water.

Studying the chemical analyses of the water from these wells, and the determinations of numbers of bacteria present, we find that many of the most polluted wells in respect to high chlorine, unoxidized nitrogen in the form of free ammonia, and oxidized or partially oxidized nitrogen in the form of nitrates and nitrites, did not show B. coli in the examinations made, in the volume of water tested for this germ.

In studying the complete chemical and bacterial analyses of all these samples, it is evident that gross previous or present pollution of the water and positive tests for B. coli in conjunction was the exception rather than the rule. That is to say, waters that at any time might become dangerous to those using them were more clearly indicated by single chemical analyses than by one or two B. coli tests, and more clearly than by determinations of the number of bacteria present.*

Examinations of Waters from Ponds and Lakes.

During the past three years 432 samples from ponds and lakes, within twenty miles of the experiment station, have been examined bacteriologically.

In the B. coli work on samples of these waters collected during 1901 and 1902, tests, when using both 1 and 100 cubic centimeters of each sample, were made, and during 1903, besides these tests, many others, when using 1,000 cubic centimeters of each sample, have been made.

Of these 432 samples, only 10 gave positive tests for B. coli when taking 1 cubic centimeter of the sample for examination. Out of 30 samples collected from the lake with the greatest population per square mile of water-shed, 5, or 13.3 per cent. of the number collected, gave positive tests. This lake is used largely for boating, fishing, etc., but not as a source of public water supply.

Lake No. 2, with the next greatest population per square mile of water-shed, gave positive tests in 1 out of 29 1 cubic centimeter samples examined. This lake is used as a source of water supply, but its shores are more or less carefully guarded, and little boating or fishing is allowed upon it.

Of the two remaining lakes, samples from which gave positive tests for B. coli in 1 cubic centimeter of water, both have a comparatively small population per square mile of water-shed, but both are used more extensively than any of the other lakes (except, perhaps, No. 1) for boating and fishing. Both, also, are surrounded by cultivated land and have picnic grounds upon their shores, those upon Lake No. 6 being liberally patronized during the summer season, and Lake No. 7 having a house of a country club, with a considerable membership, upon its shores. This house is used, more or less, every pleasant summer afternoon, and quite extensively upon Saturdays and Sundays. Much boating and fishing take place.

Studying the results of tests for B. coli in these waters when taking larger volumes than 1 cubic centimeter for examination, it will be seen, that with one exception, even those lake waters not responding positively to this test when taking 1 cubic centimeter gave occasional positive tests when as large a volume of water as 100 cubic centimeters was taken, and that when 1 liter was taken, the percentage of positive tests again increased in every instance but one. The results show with considerable clearness that in the examination of surface waters from inhabited localities, the question of obtaining positive tests for B. coli is only one of taking a sufficient volume of water for the test. They also indicate that the degree of contamination of these waters varies inversely as the volume required to give a positive test for B. coli.

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* An article, presenting a thorough discussion of all the results of inspection of the wells and their surroundings, together with chemical and bacterial analyses of these well waters, is to appear in a subsequent report of the Board.

A list of these lakes by number, with data in regard to the area of water surface of each lake, area of water-shed, population per square mile of water-shed and total population upon the water-shed, together with the results of tests for B. coli in different volumes, and the excess of chlorine above the normal, are shown in Table No. 4.

TABLE NO. 4. — *Showing Results of Tests for B. Coli in Surface Waters.*

NUMBER.	Area of Water Surface (Acres).	Area of Water-shed (Square Miles).	Population of Water-shed per Square Mile.*	Total Population of Water-shed.*	1 CUBIC CENTIMETER.				100 CUBIC CENTIMETERS.			1,000 CUBIC CENTIMETERS.			Excess of Chlorine above Normal.
					Number of Samples.	Average Number of Bacteria per Cubic Centimeter.	Per Cent. of Samples fermenting Dextrose.	Per Cent. of Samples containing B. Coli.	Number of Samples.	Per Cent. of Samples fermenting Dextrose.	Per Cent. of Samples containing B. Coli.	Number of Samples.	Per Cent. of Samples fermenting Dextrose.	Per Cent. of Samples containing B. Coli.	
1,†	243	5.00	1,400	7,000	30	612	53.3	13.3	30	60.0	33.0	18	78.0	45.0	.65
2, ...	85	0.94	356	380	29	319	13.8	3.5	29	38.0	17.2	18	67.0	45.0	.18
3, ...	105	0.88	116	102	13	103	0.0	0.0	13	7.7	0.0	-	-	-	.23
4, ...	291	6.40	90	575	43	170	18.6	0.0	43	30.2	14.0	18	78.0	45.0	.21
5, ...	262	9.47	62	580	45	87	0.0	0.0	45	26.7	9.0	19	79.0	32.0	.07
6,†	222	4.96	60	290	44	48	13.6	2.3	44	38.6	4.5	19	63.2	16.0	.05
7,†	621	5.40	50	270	43	66	16.3	4.6	43	35.0	21.0	18	67.0	33.3	.05
8, ...	38	0.32	47	15	45	133	11.1	0.0	45	29.0	9.0	19	58.0	32.0	.08
9, ...	145	3.18	42	125	45	131	8.9	0.0	45	24.5	6.7	19	63.0	32.0	.00
10,†	200	2.70	40	108	32	31	31.2	0.0	32	25.0	6.2	18	50.0	0.0	.00
11, ...	135	1.87	8	25	13	28	0.0	0.0	13	53.8	7.7	-	-	-	.00
12, ...	379	5.18	42	148	43	107	20.9	0.0	43	42.0	9.3	18	67.0	22.0	.00

* Approximate.

† Shores used for pleasure resorts.

On the Change in the Numbers of B. Coli in Water during Storage.

As many examinations for B. coli have been made of samples of waters from storage reservoirs or impounded waters, some knowledge of the change which takes place in the number of B. coli in waters of this class during the period of storage has been gained. These data have been collected in four tables, as follows: 1, the change which takes place in a body of water considerably polluted and which has a continuous but irregular flow of water through it; 2, the change which takes place in a storage reservoir through which there is a nearly constant flow of water; 3, the change which takes place in a storage reservoir which, being once polluted, stands stagnant without further pollution.

1. As a type of the first class we have the Merrimack River above Lawrence. The distance from the Lowell sewer outfalls to the Lawrence dam is approximately ten miles, and from a point about one and one-half miles below the sewers to the Lawrence dam there is only a slight fall, so that during periods of low water all of the water is held back by flashboards on the dam and passes through the Essex Company's canals. A number of series of samples have been taken at different points along the river between Lowell and Lawrence, and the analyses of these samples, as far as the data concern the colon problem, have been collected in Table No. 5.

At each location covered by the investigation a number of samples were taken from the surface, from near the bottom and from a depth midway between the surface and the bottom, at two or three points directly across the river. Analyses of all of these samples were then averaged, and the averages are the figures that appear opposite the various distances in the table. In the series numbered I. the numbers of B. coli are averages of three such samples. In each of the other three series quoted the numbers of B. coli are averages of six samples in each case. At the times when these series were taken the water in the river was low and there was only a slight current, caused by the draught of water by the mills, upon this storage basin.

The results did not show any regular difference between samples at the surface and at the bottom of the river, or between samples taken near the shores or in mid-stream. The average results as quoted are very erratic, and show no regular decrease in numbers of B. coli in the distance of nine miles covered by the investigation. The numbers are slightly higher in three out of the four series in samples collected at a distance of three miles below the sewers than at one and one-half miles, and in two out of four series the results are higher at a distance of five miles below the sewers than at the two locations nearer the sewers. In one series the highest results were obtained at a point seven miles below the sewers. Series number II. illustrates the effect of a sudden influx of water. Three of the locations had been covered on the date on which it was intended to take this series. Before samples were obtained from the two points farthest from the sewer outfalls, the work was interrupted by a heavy rainfall, and the samples from these two points could not be taken until some eighteen hours later. The decrease in numbers of B. coli in these last two results over the three preceding results is very marked. The results of these series are shown in Table No. 5: —

TABLE NO. 5. — *Showing Numbers of Bacteria of the Colon Type in the Merrimack River at Various Distances below the Lowell Sewer Outfall.*

DISTANCE BELOW SEWER OUTFALL (MILES).	AVERAGE NUMBER OF BACTERIA OF THE COLON TYPE PER CUBIC CENTIMETER.			
	Series I.	Series II.	Series III.	Series IV.
1½,	30	23	32	103
3,	55	28	36	69
5,	18	73	77	21
7,	106	11*	71	5
9,	42	11*	24	23

* Series interrupted by heavy rain, continued on following day.

2. During 1900 an experiment was made as follows: a large tank, twelve feet in depth, was filled with Merrimack River water and so arranged that a small stream of water could be applied to the surface, and by a pipe passing from the bottom of the tank up to the surface and then out through the side of the tank the inflow of water forced out an equal amount from the bottom of the tank. The tank was so arranged that samples could be drawn from the inlet, outlet and from a number of points at different depths without stirring up the water in the tank. Merrimack River water was applied to this tank continuously for twelve to eighteen hours a day in such volumes that the water in the tank should have twenty days' storage, thus imitating as nearly as possible on a small scale a municipal resorvoir, with twenty days' storage capacity. Here we had an opportunity to study: first, the change taking place in the numbers of bacteria in the water, and second, to determine whether or not there was any sedimentation of bacteria, the Merrimack River water for the experiments being practically free from suspended matter which would tend to settle out, carrying some of the bacteria with it. During the first five weeks of the experiment the numbers of B. coli in the water gradually diminished, until at the end of this period they were not found in 1 cubic centimeter, the organisms being found during this period in 16 per cent. of the samples collected at depths of six and twelve feet below the surface. During the eleven weeks following, B. coli were not found in any sample from either of three depths, although the average number of B. coli in the applied water was double the number in

the applied water during the first five weeks. Beginning with the seventeenth week of the experiment, a small portion of sewage was mixed with the Merrimack River water applied to the tank to increase the numbers of B. coli, this being continued during four weeks. The average number of B. coli in the influent during this period was 615 per cubic centimeter, but the numbers of B. coli in the samples of reservoir water remained very low throughout, and the organism was found in only 10 per cent. of the samples from each of the three points, namely, surface, six feet deep and twelve feet deep. The averages of results obtained during this experiment are shown as follows, in Table No. 6: —

TABLE NO. 6. — *Showing Change in the Number of Bacteria of the Colon Type in a Storage Reservoir having a Continuous Inflow and Outflow.*

CHARACTER OF INFLUENT.	Period.	INFLUENT.		RESERVOIR.		
		Average Number of Bacteria of the Colon Type per Cubic Centimeter.	Per Cent. of Samples containing Bacteria of the Colon Type.	PER CENT. OF SAMPLES CONTAINING BACTERIA OF THE COLON TYPE.		
				Surface.	Six Feet deep.	Twelve Feet deep.
Merrimack River,	Five weeks,	6	100	16	20	20
Merrimack River,	Eleven weeks,	12	100	0	0	0
Merrimack River and sewage,	Four weeks,	615	100	10	10	10

Other data on the change in the colon contents of water in a storage reservoir have been obtained by the routine analyses of the effluent of the Lawrence city filter, and of the same water after passing through the distributing reservoir of the city of Lawrence. This reservoir has a capacity, when full, of 40,000,000 gallons, and the consumption of water in the city of Lawrence varies between 3,000,000 and 5,000,000 gallons per day, giving an average storage of about ten to twelve days in the reservoir. Determinations of B. coli have been made in one cubic centimeter of each of these waters since 1898, daily samples being taken during the winter months and usually not less than one sample per week, of each, during the warmer months. During the last three and one-half years, tests for B. coli have also been made in 100 cubic centimeters, and the yearly results of the analyses of both volumes are shown in Table No. 7.

In the 1 cubic centimeter tests a reduction of nearly one-half in the percentage of samples containing the type organism occurred as the water passed through the reservoir. In only one year, 1898, were a greater percentage of plus results found in the effluent than in the influent, and this abnormal result may possibly be attributed to the fact that the methods of testing for B. coli were at that time not as perfect as at present. As would be expected, a considerably greater number of samples contained B. coli in the larger volume than in the smaller volume, but the ratio between the influent and the effluent of the reservoir remained practically the same, whichever volume was used as a means of comparison. In this instance the water was one from which the normal bacteria had been largely removed by filtration, and one whose chemical contents had been changed to a considerable extent by biological processes, so that it contained much of its nitrogen in a different form from that in Merrimack River water, and which might be supposed to be in a condition to support a development of bacterial life in the storage reservoir; nevertheless, a constant elimination of germs of the colon type occurred. The yearly averages of analyses of influent and effluent of this reservoir are shown as follows, in Table No. 7: —

TABLE NO. 7. — *Showing Change in the Percentages of Bacteria of the Colon Type in Water before and after passing through the Lawrence Storage Reservoir.*

YEAR.	PER CENT. OF SAMPLES CONTAINING BACTERIA OF THE COLON TYPE.			
	IN 1 CUBIC CENTIMETER.		IN 100 CUBIC CENTIMETERS.	
	Effluent from City Filter.	Outlet of Reservoir.	Effluent from City Filter.	Outlet of Reservoir.
1898,	19	20	-	-
1899,	23	13	-	-
1900,	18	9	38	23
1901,	7	3	28	20
1902,	4	1	8	5
1903 (6 months only),	4	1	15	3
Average,	13	7	21	11

3. An experiment in regard to the change in numbers of bacteria of the colon type in a storage reservoir once polluted but allowed to stand stagnant without further pollution was made as follows: a large tank, twelve feet deep, fitted with pipes, through which samples for analyses could be drawn from different points in the tank and at various levels, was filled with Merrimack River water. Daily analyses were made of the water from the various portions of the tank, this being continued as long as B. coli were found to be present in any portion of the tank. The numbers of B. coli per cubic centimeter, one hour after filling the tank, were 32 at the surface, 22 at a point six feet deep, and 9 at the bottom of the tank. After twenty-four hours the natural intermixture of the water in the tank had caused a practical equalization of the numbers, these being 18 each at the surface and at the bottom, and 15 at a point midway. There was a gradual diminution in numbers of B. coli, the results fluctuating somewhat at the various levels, this fluctuation being due probably more to unavoidable errors in sampling and in bacteriological methods than to any material

difference in the bacterial contents of water from different portions of the tank. After eleven days B. coli were found in only one sample, this being collected near the bottom of the tank. On the twelfth day and later B. coli were not found in the water from any portion of the tank, and on emptying the tank on the fifteenth day, analyses of scrapings from the bottom of the tank showed the complete absence of the organism. The average daily results of analyses of water from three levels in this tank are shown as follows, in Table No. 8: —

TABLE NO. 8. — *Showing the Change in Numbers of Bacteria of the Colon Type at Various Depths in a Stagnant Storage Reservoir.*

ELAPSED TIME.	AVERAGE NUMBER OF BACTERIA OF THE COLON TYPE PER CUBIC CENTIMETER.			ELAPSED TIME.	AVERAGE NUMBER OF BACTERIA OF THE COLON TYPE PER CUBIC CENTIMETER.		
	Surface.	Six Feet deep.	Bottom, Twelve Feet deep.		Surface.	Six Feet deep.	Bottom, Twelve Feet deep.
Start, . . .	32	22	9	7 days, . . .	3	5	4
24 hours, . .	18	15	18	8 " . . .	3	2	4
2 days, . . .	15	8	7	9 " . . .	2	7	8
3 " . . .	8	10	6	10 " . . .	4	4	2
4 " . . .	3	7	4	11 " . . .	0	0	3
5 " . . .	5	0	–	12 " . . .	0	0	0

EXAMINATIONS OF SHELL-FISH.

During the past three years considerable work has been done at the experiment station in examining shell-fish, such as clams, oysters and quahaugs, for evidence of pollution. In this work tests for B. coli and for the sewage streptococcus in the shell-fish itself and in the water in its shell have been made. Many samples of the sea water, taken at the localities in which the shell-fish have been gathered, have also been examined.

Enough study has been made by many investigators to show clearly that B. coli is not a normal inhabitant of the intestines of clams or oysters, and that its presence in the intestines or juice in the shell must be due to contamination either by drainage and sewage flowing over the clam and oyster beds, or by careless and uncleanly handling of the shell-fish between the time of digging and placing upon the market. In this work, therefore, the ability to demonstrate clearly the presence of a specific sewage organism, such as B. coli, is an invaluable aid in determining the question of purity or pollution. In many samples from polluted sources B. coli has not been found in either shell water or intestine. This is not to be wondered at, however, as among the many bacteria normally present or finding lodgment in the intestine or in the shell water, the stronger and more numerous species may evidently destroy the B. coli before laboratory examination is possible.

A following table shows the number of samples of shell-fish examined, together with a more or less accurate statement as to the character of the source from which these fish were taken.

TABLE NO. 9.— *Showing Results of Tests for B. Coli in Shell-fish and Sea Water from Polluted and Non-polluted Sources.*

Character of Source.	Number of Sources.		Number of Samples.		Per cent. of samples positive.					
					Shell-Fish.				Sea Water.	
					Shell Water.		Intestine.			
	Shell-fish.	Sea Water.	Shell-fish.	Sea Water.	Presumptive Test.	Colon Type.	Presumptive Test.	Colon Type.	Presumptive Test.	Colon Type.
Not polluted,	15	10	44	37	0	0	25	0	3	0
Doubtful, .	22	19	114	80	30	8	71	6	51	17
Polluted, .	6	4	49	48	75	41	84	35	67	44

In some instances bacteria of the sewage streptococcus type are known to interfere with the colon tests by overgrowing and destroying fermenting organisms of the colon type in the presumptive test after these organisms have produced sufficient gas to give a presumptive test. This, however, would not account for the lower numbers of B. coli found at points near the sewer outlet, as, while this organism was found frequently in samples near the sewer outlet, the greatest percentage of samples containing it were found, as stated previously, some one-half to three-fourths of a mile away from the sewer. The surface of this clam bed, however, near the sewer outlet, and extending perhaps one-eighth to one-fourth of a mile away, was covered with a layer of slime (sewage sludge) in an active state of putrefaction, and, as is well known, the organisms of putrefaction are inimical to bacteria of the colon type.

In a table following it will be noticed that of the samples of clams taken at known distances from a sewer outlet, the greatest percentage giving positive tests were collected one-half to three-fourths of a mile from this outlet. The water samples collected from one-eighth of a mile to one and five-eighths miles from the sewer outlet also gave a greater percentage of positive tests for B. coli. Those collected at a distance of one-fourth to one-half a mile also gave a greater percentage of positive tests for B. coli than did the samples collected nearer the outlet. These results are further evidence in regard to the destruction of B. coli in polluted samples of water and clams by other bacteria between the time of collection and the time of laboratory examination.

TABLE NO. 10.—*Showing Results of Tests for B. Coli in Shell-fish collected at Known Distances from a Sewer Outlet.*

Distance from Sewer Outfall (Miles).	Number of Samples.		Per cent. of Samples Positive.								
			Shell-fish.						Sea Water.		
			Shell Water.			Intestines.					
	Shell-fish.	Sea Water.	Presumptive Test.	Colon Type.	Sewage Strepto-coccus Type.	Presumptive Test.	Colon Type.	Sewage Strepto-coccus Type.	Presumptive Test.	Colon Type.	Sewage Streptococcus Type.
$0-\frac{1}{8}$, ...	34	5	82	53	26	85	12	79	100	40	20
$\frac{1}{8}-\frac{1}{4}$, ...	20	3	80	45	30	75	30	65	100	67	33
$\frac{1}{4}-\frac{3}{8}$, ...	22	4	73	36	55	55	27	77	100	100	0
$\frac{3}{8}-\frac{1}{2}$, ...	26	4	73	46	31	85	31	88	100	100	0
$\frac{1}{2}-\frac{3}{4}$, ...	15	4	87	80	53	73	40	80	100	75	0
$\frac{3}{4}-1$, ...	9	2	100	44	11	78	11	89	100	50	0
$1-1\frac{1}{4}$, ...	11	3	100	55	24	91	18	73	100	100	0
$1\frac{1}{4}$ to $1\frac{5}{8}$, ...	9	3	78	33	33	78	11	89	100	33	0
$0-1\frac{5}{8}$, ...	146	28	81	49	34	77	23	79	100	71	7

THE SO-CALLED PRESUMPTIVE TEST AND ITS SIGNIFICANCE.

In some laboratories work upon the determination of fecal bacteria of the colon type is limited to what is known as the presumptive test, that is, the formation of gas in dextrose broth inoculated with a sample of the water under examination. In other laboratories the procedure corresponds with that used at Lawrence, except that the test for indol or that for the reduction of nitrates is omitted. The use of the presumptive test without further confirmation may lead to an erroneous idea as to the character of the sample.

A study of the various compilations of bacterial descriptions shows that there are at least 58 well-described species of bacteria of five primary types which would give positive results; that is, be designated as colon bacilli, if we depended upon a presumptive test alone.

Of these 58 species, 12 would be included in the colon type, as it is interpreted at Lawrence, these being B. coli, Escherich, from feces; culture C (A. P. H. A. Bact. Comm.); Bact. Nos. 108 and 116, and B. Nos. 49, 50, 51, 58, 67, 86, 107 and 135, Gage, from water.

Three species are of the so-called paracolon (B) or chologenes type, that is, bacteria identical with those in the colon type, with the exception that nitrous acid is not formed in nitrate pepton solution, these being Bact.

asthenæ, Dawson, from fowls' intestines; Bx. chologenes, Kruse, from Angio-colitis; and B. No. 56, Gage, from water.

Seven species belong to the so-called paracolon (A) type, or the aerogenes, or enteritidis, Gärtner, groups; that is, bacteria identical with the colon type with the exception that indol is not produced in pepton solutions. These are Bact. aerogenes, Escherich, B. coli-immobilis, Kruse, B. No. 133, Gage, from feces; Bx. enteritidis, Gärtner, from decayed meat; Bact. fermentationis, Chester, from soil; Bact. pallescens, Henrici, from cheese.

Thirteen species would give positive reactions by the presumptive test, in which the descriptions are not sufficiently well worked out to identify them with or exclude them from the three preceding groups. These are Str. mesenteroides (Cienkowski), Migula, from saccharose solutions; Str. agalactæ, Adametz, from mastitis of cows; Bact. acidi-formans, Sternberg, from yellow fever cadaver; Bact. emphysematosum, Kruse, from gaseous phlegmon; Bact. chinense (Hamilton), Chester, from India ink; Bact. Wrightii, Chester, from broncho-pneumonia; Bact. endometriditis, Kruse, from abscess of the liver; Ps. ambigua, Wright, from water; B. Marsiliensis, Kruse, from swine plague; B. Wardi, Chester, from milk; B. muripestifer, Kruse, from mice plague; B. thermophilis, Chester.

Besides these there are 23 species which would show positive results when tested by the presumptive test alone, which would be readily thrown out by subsequent tests and would never be included in either of the first three groups. These are Ps. monadiformis, Kruse, Bx. icterogenes, Kruse, from feces; Bx. aerogenes, Schow, from urine; Ps. sinuosa, Wright, from water; Bact. No. 110, Gage, from ground water, and Bact. No. 117, Gage, from filtered water; Bx. muscoides-colorabilis, Ucke, from soil; Bact. sputigenum (Herla), Chester, from sputum; Bact. pneumoniæ, Zopf, from saliva; Bact. ozænæ (Abel), Lehman-Newman, from nasal mucus; Bact. viscosum, Van Laer, from beer, yeast and bread; Bact. Nos. 62 and 136, Gage, from shell-fish; Bact. Bordonii (Trevisan), Chester; Bx. loxiacida, Tartakowsky, from disease of birds; Bx. murium, Löffler, Bx. Poelsii, Chester, B. Silberschmidii, Chester, and B. Breslaviensis, Kruse, from decayed meat; B. levans, Lehman-Wolffin, from sour dough; B. columbarum, Chester, from pigeon cholera; B. Salmonii, Trevisan, from hog cholera; and Spirochaeta febris, Chester, from recurrent fever.

In the Lawrence work, species belonging to the first-mentioned or colon group only are included under the name "B. coli," that is, only those cultures responding positively to all the tests included in the "Lawrence B. coli methods," first described in the report for 1898, page 533; and again, with minor changes due to continued studies, in the report for 1901, page 397.

In studies previously reported[3] it was shown that the presumptive test had an efficiency of from 40 to 60 per cent. as an indication of the presence of B. coli. This factor has varied greatly with the character of the sample and with the degree of pollution. For filtered waters the presumptive test, followed by the litmus lactose agar plate and the appearance of the growth on the agar streak, would enable an experienced observer to judge very closely as to the presence or absence of B. coli. For a person without wide experience, however, the error of such judgment might be considerable. The presumptive test in itself, without these confirmations, would, even to the experienced observer, be very difficult of interpretation. In the examination of surface water supplies, as previously shown in Table No. 4, the presumptive test in small volumes would appear to be of little value. As the volume was increased, however, to 100 cubic centimeters the presumptive test gave results which agreed very closely with the probable pollution as indicated by the population on the water-shed of the various lakes, and with liter samples this connection between the probable pollution and the presumptive test was even closer.

In an examination of well waters of different types the presumptive test frequently gave positive results where the absence of B. coli, and the general character of the samples from all stand-points, showed the samples to be entirely above suspicion. In the examination of shell-fish the presumptive test alone would lead to very erroneous results. In Table No. 10 it is shown that even with the shell-fish from sources known to be grievously polluted a positive result was obtained with the presumptive test in about 80 per cent. of the samples. In Table No. 9 the positive presumptive test with samples which were known to be remote from pollution were very misleading, 25 per cent. of the examinations of the intestines of shell-fish from such sources, and 3 per cent. of the samples of sea water from those sources, giving a positive presumptive test, although B. coli or other fecal bacteria were not found. In the examination of milk over 14 per cent. of the samples showed a positive presumptive test, but something less than 4 per cent. of the samples showed fecal bacteria when the tests were concluded.

In Table No. 11 we find that 5 per cent. of the samples of ice gave us a positive presumptive test in 1 cubic centimeter, as compared with 3 per cent. positive in 100 cubic centimeters. The findings of B. coli, however, were 1 per cent. in 1 cubic centimeter and 2 per cent. in 100 cubic centimeters, probably nearer the true relation.

Significance of the Various Test Types.

Of the various forms of bacteria used as indices of sewage pollution, the principal ones are B. coli, the sewage streptococcus and B. sporogenes. Of these, B. coli has formed a basis for the greatest amount of work; nevertheless, the other two have considerable standing among various observers in different parts of the world. B. coli is supposed to show present or past pollution, usually, recent pollution. The streptococcus type, it is stated, should show only very recent pollution by sewage; evidence as to this, however, has not been forthcoming. The Bacillus sporogenes, being a spore-forming organism, may show present pollution and it may also show pollution which has occurred at some previous time, and from which the danger has now entirely ceased. The two so-called paracolon types, that is, the aerogenes, or enteriditis, Gärtner, type and the chologenes type, are introduced here merely because in some laboratories one or the other is included under the colon type. As to the distribution of the colon, aerogenes and chologenes types, there is a large amount of data. The data concerning the streptococcus type is not as complete. Houston[4] describes twenty-one cultures, among which there appear to be at least seven distinct species, while the same number of species have been isolated and described at the experiment station.[5] Winslow and Hunnewell[6] report the finding of sewage streptococci in a variety of apparently unpolluted samples. It certainly is a fact that micrococcus forms in general are abundant in the air and in soil, and it is probable that more extended study will show them to be of as wide variety as are the other forms of bacterial life. The data concerning B. sporogenes, belonging as it does to that restricted and little studied group of bacteria, the pathogenic, spore-forming, obligate anaerobes, are very meagre indeed. While at present we know of only two other species which would be included by the usual sporogenes test, more study is required before we accept this test as final.

In examinations of water or other substances for present pollution, tests for the specific organism which is believed to be the best index of pollution, which is most numerous in sewage and for which the tests are most exact, will be of the most value, always assuming that this organism is characteristic of sewage and is not found, or at least only occasionally found, in sources removed from pollution. Examinations of sewage at the experiment station show that in dilutions of $\frac{1}{10000}$ we may expect to find B. coli in 95 per cent. of the samples, and that we may identify the sewage streptococcus in 67 per cent. of the samples. A dilution of $\frac{1}{50000}$ cuts the percentage of positive tests for B. coli to 78 per cent. of the samples, and the percentage of streptococcus to 6 per cent. of the samples. In dilutions of $\frac{1}{100000}$ B. coli was found in 40 per cent. of the samples, and in a dilution of $\frac{1}{1000000}$ B. coli was found in 6 per cent. of the samples. The sewage streptococcus could not be identified in dilutions greater than $\frac{1}{50000}$. B. sporogenes can usually be detected in dilutions of $\frac{1}{500}$ to $\frac{1}{1000}$, but in dilutions greater than this it is only very rarely detected. In other words, we may expect to obtain a diagnosis with B. coli in such dilutions that the presence of B. sporogenes or of the sewage streptococcus could not be detected.

During a period of six months in 1902 and 1903, daily examinations were made for these three organisms in the Merrimack River water and in the effluent from the Lawrence city filter. In the polluted river water, and when taking 1 cubic centimeter, B. coli were found in 99 per cent. of the samples examined, bacteria of the sewage streptococcus type were found in 45 per cent. of the samples and B. sporogenes was found in only 24 per cent. of the samples. In one month, when B. coli were found in 100 per cent. of the samples examined, B. sporogenes was found in only 4 per cent. of the samples, and in another month, when B. coli was found in 96 per cent. of the samples, the sewage streptococcus was not found. In the filtered water, B. coli was found in 5 per cent. of the 1 cubic centimeter samples and in 10 per cent. of the 100 cubic centimeter samples. The sewage streptococcus was not found when taking volumes as large as 100 cubic centimeters. B. sporogenes was not found in 1 cubic centimeter, but was found in 14 per cent. of the 100 cubic centimeter samples. The ratio between positive results in 1 cubic centimeter and 100 cubic centimeter samples for B. coli was as 1 is to 2, which is approximately the ratio we have found normally occurring with filtered waters. The ratio between the 1 cubic centimeter and 100 cubic centimeter tests for B. sporogenes was as 0 to 14.

During a period of four months in 1903, samples of milk from Lawrence dealers were tested daily for fecal bacteria. B. coli was found in 4 per cent. of these samples and bacteria of the sewage streptococcus type were found in 3 per cent. of the samples. Bacteria of the chologenes type were present in 1 per cent. of the samples and bacteria of the aerogenes type were not found. Organisms giving all the characteristics of B. sporogenes were found in 10 per cent. of the samples, these sporogenes tests, however, not being confirmed by animal inoculation.

The relative distribution of these various type forms, with the exception of B. sporogenes, in nearly 3,000 samples of eleven different kinds during one year is shown in Table No. 11.

TABLE NO. 11. — *Showing Relative Distribution of Bacteria of the Colon, Cologenes, Aerogenes and Sewage Streptococcus Types during One Year, ending June 30, 1903.*

CLASS OF SAMPLES.	Total Number of Samples.	PER CENT. OF SAMPLES POSITIVE.														
		PRESUMPTIVE TEST.			COLON TYPE.			SEWAGE STREPTOCOCCUS TYPE.			AEROGENES TYPE.			CHOLOGENES TYPE.		
		1 c. c.	100 c. c.	1,000 c. c.	1 c. c.	100 c. c.	1,000 c. c.	1 c. c.	100 c. c.	1,000 c. c.	1 c. c.	100 c. c.	1,000 c. c.	1 c. c.	100 c. c.	1,000 c. c.
Filtered water,	1,722	14.0	24.0	-	6.0	13.0	-	0.1	0.5	-	1.9	1.9	-	0.5	0.4	-
Shallow wells,	456	8.0	7.5	-	2.2	3.1	-	0.0	0.2	-	0.7	0.7	-	0.0	0.2	-
Curb wells,	48	2.1	21.0	-	0.0	6.2	-	0.0	4.2	-	0.0	0.0	-	0.0	0.0	-
Tubular wells,	57	1.7	17.0	-	0.0	1.7	-	0.0	1.7	-	0.0	0.0	-	0.0	0.0	-
Municipal ponds and lakes,	128	12.0	38.0	48	0.0	19.0	20	0.0	6.0	12.0	0.0	0.8	0.8	0.0	0.0	1.6
Miscellaneous ponds and lakes,	41	61.0	29.0	-	2.4	4.9	-	4.9	7.3	-	4.9	2.4	-	0.0	2.4	-
Filter galleries,	18	11.0	33.0	-	0.0	17.0	-	0.0	5.6	-	17.0	5.6	-	0.0	0.0	-
Rivers and brooks,	59	53.0	64.0	-	34.0	41.0	-	1.7	3.4	-	3.4	1.7	-	3.4	0.0	-
Shell-fish and sea water,	284	81.0	-	-	39.0	-	-	55.0	-	-	11.0	-	-	6.3	-	-
Lawrence ice,*	103*	5.0	3.0	-	1.0	2.0	-	0.0	0.0	-	1.0	0.0	-	0.0	0.0	-
Lawrence milk,	79	14.0	-	-	4.0	-	-	3.0	-	-	0.0	-	-	1.0	-	-
Total number of samples examined,	2,995	2,995	2,632	128	2,995	2,632	128	2,995	2,632	128	2,995	2,632	128	2,995	2,632	128
Per cent. of samples positive,	-	20.0	23.0	48	8.4	11.0	20	5.5	1.2	1.2	2.5	1.5	0.8	1.0	0.3	1.6

* Including examinations extending over three years.

RELATIVE VIABILITY OF B. COLI AND B. TYPHOSUS.

While we interpret our colon tests only in the light of their indication of fecal pollution, many bacteriologists have an underlying if not freely expressed opinion that B. coli has a greater significance. That this opinion is prevalent is indicated by the numerous articles in which B. coli and B. typhosus are compared, especially by bacteriologists working along pathological lines, many of whom have sought to show an interrelation between the two species, with allied species or races filling in the gap between the two, until we have a gradation of forms from one to the other, and the introduction of the terms paracolon and paratyphoid.

Furthermore, it is believed by many that B. coli and some of the so-called paracolon types are in themselves the cause of intestinal and digestive disorders, and even of maladies closely approaching typhoid fever. In the recent epidemic of typhoid at Ithaca, N. Y., attending physicians diagnosed no less than 16 cases as paracolon fever, and one death from that cause was given. Allen[7], in a recent paper, reviews at length the various supposed paracolon infections in the United States. Valagressa[8] has traced the cause of epidemic diarrhœa in Italy to the toxins of B. coli and allied types (paracolon?), and has succeeded in producing a similar infection in animals by inoculation with the toxins from experimental cultures of these germs. A report from Russia[9] announces an epidemic disease of horses undoubtedly caused by B. coli. Curtice[10] reports an epidemic disease among fowls in which the colon bacillus was constantly present, together with another pathogen in the feces of all cases examined. Other reports have ascribed to B. coli as the cause or accompaniment of various maladies, as spinal meningitis, brain disorders, etc.

While the position taken by some writers, that B. coli and B. typhosus are identical, or are strains or races from the same original stock, is untenable in the light of all present knowledge of the subject, nevertheless, certain points of similarity do exist in the biological history of the two species, and especially in the behavior of laboratory cultures of these germs towards certain adverse conditions.

The following studies concerning the relative behavior of the two species have been made at Lawrence: as regards

1. Removal from water by sand filtration.
2. Persistence in the filtering material of a sand filter through which a current of water is constantly passing.
3. Their viability when subjected to cold without freezing.
4. Their elimination by the formation of ice upon a body of water.
5. Their elimination by complete freezing of a body of water.
6. Their viability in ice.
7. Their resistance to heat.
8. Their resistance to sunlight.

THE RELATIVE BEHAVIOR OF B. COLI AND B. TYPHOSUS IN WATER DURING SAND FILTRATION.

In 1892,[11] the removal of B. typhosus by sand filters was studied at Lawrence, a decrease in the numbers of these germs after filtration of between 99 and 100 per cent. being noted.

In 1900,[12] two experimental filters were operated with water enriched with both B. coli and B. typhosus, the studies being so conducted, first, as to show the relative removal of the two types by filters in normal condition, when the type organisms were continuously present in considerable numbers in the applied water; and, second, to determine how long the test germs would continue to be present in the effluents from the filters after the infecting material ceased to exist in the applied water.

1. *Relative Removal from Water by Sand Filtration.*

During the first portion of the experiments, the average daily number of B. coli per cubic centimeter in the applied water was 525 and the number of B. typhosus was 282. The number of B. coli was greater than we have ever found to be present in the Merrimack River, while the number of typhoid germs was undoubtedly greater than would ever be present in any water which was to be purified for domestic use. For this reason the tests of the filters were unusually severe. During this period the intermittent filter removed 98.7 per cent. of the total bacteria, 99.9 per cent. of the B. coli and 100 per cent. of the B. typhosus. B. coli was found in 26 per cent. of the samples and B. typhosus was not found at all.

In the continuous filter, 98.7 per cent. of the total bacteria were removed, 99.8 per cent. of the B. coli and 99.9 per cent. of the typhoid germs, B. coli being found in 22 per cent. of the samples and B. typhosus in 4 per cent.

2. *Persistence of the Two Species in the Filtering Material.*

In order to determine the persistence of the test germs in the effluents, after the infection of the applied water had ceased, immense numbers of each were mixed with the water for some days, until the germs were uniformly present in the effluents; water free from both germs was then turned on to the filters and tests made until the germs were found not to be present in the filtered water. In the case of the intermittent filter, B. coli was found to be present in the effluent during twenty-four to thirty-six hours after the infection had ceased, while all of the B. typhosus were eliminated in a few hours. With the continuous filter, B. coli persisted in the effluent four to six days, while the typhoid germ was not found after the second day.

THE EFFECT OF COLD ON B. COLI AND B. TYPHOSUS.

Considerable literature exists with regard to the effect of cold and freezing upon B. typhosus, and a few papers include results of the investigations also with B. coli. Sedgewick and Winslow[13] give a very complete bibliography of the subject up to 1901; recent contributions by Park[14] and Brehme,[15] and an article[16] in the report of the Board for 1900, have added valuable data on the subject.

The studies of the effect of cold on B. coli and B. typhosus at the Lawrence Experiment Station have been carried out in three different experiments; first, the viability of the organisms in water when kept at a temperature just above the freezing point, this being the condition which exists in our rivers in cold climates during the winter season; second, the elimination of the germs by freezing; in this case we have the combined effect of the cold, more intense than is possible with a water culture, and the mechanical effect of freezing, either the mechanical throwing out of extraneous matter when the freezing occurs in the open, or the crowding effect which takes place when the whole body of the liquid is frozen; third, the longevity of the germs in the frozen condition.

3. *Viability when subjected to Cold without Freezing.*

The results illustrating this phase of the study have been compiled from two sources. In a considerable number of our experiments on the elimination of bacteria by freezing, frequent analyses were made of samples of the water from under the ice. The numbers of bacteria in this water have been subjected not only to the effect of low temperature but also to the effect of sedimentation, and to a slight increase during the elimination of the bacteria on the surface layers in the formation of ice. The effect of sedimentation in clear waters, such as the ones used in these experiments, is very slight, as has been shown before. As a control, however, experiments were also made with water in bottles suspended in tanks at a temperature just above freezing. The results obtained have varied among themselves very considerably.

With B. coli, in one instance no living germs were found on the twelfth day, in another instance they had disappeared on the fifteenth day, while in another instance they did not disappear until the twenty-first day. In two experiments 99 per cent. of the B. coli had disappeared on the fourth day, while in another instance the number of germs found on the eighth day was greater than at the start.

With B. typhosus, in one experiment the germs had disappeared on the fifth day, in another they had disappeared on the eighth day, while in two other instances the germs were found to be present in small numbers on the tenth and twelfth days, respectively. The results of these experiments are shown in Table No. 12. Experiments so few in number, however, have no great significance, and the fact that B. coli and B. typhosus can live for much longer periods under more adverse circumstances is shown by further experiments.

TABLE NO. 12.— *Showing the Relative Viability of B. Coli and B. Typhosus in Water at a Temperature of 33° F.*

NUMBER OF DAYS.	B. COLI PER CUBIC CENTIMETER.						B. TYPHOSUS PER CUBIC CENTIMETER.			
	TANK EXPERIMENT.				BOTTLE EXPERIMENT.		TANK EXPERIMENT.			BOTTLE EXPERIMENT.
	I.	II.	III.	IV.	I.	II.	V.	VI.	VII.	III.
Start, ...	750	211	2,400	25,900	1,530	25	21,700	71,800	1,700	1,500
1, ...	630	-	-	-	260	11	-	2,100	-	312
2, ...	-	-	-	-	398	3	-	-	69	15
3, ...	-	-	196	-	372	17	600	-	-	4
4, ...	-	478	21	74	226	1	500	-	-	1
5, ...	-	-	-	-	63	1	-	285	6	0
6, ...	-	179	-	1,885	-	-	-	-	-	0
7, ...	-	-	-	-	15	12	-	106	-	0
8, ...	-	328	-	1,115	-	-	-	-	0	0
9, ...	6	-	-	-	15	+	-	-	-	-
10, ...	7	-	-	-	-	-	-	12	-	-
11, ...	-	51	-	47	15	+	-	-	-	-
12, ...	-	14	0	29	-*	-	21	-	-	-
13, ...	-	-	0	-	-	-	-	-	-	-
14, ...	-	-	-	-	-	+	-	-	-	-
15, ...	-	1	-	0	-	-	-	-	-	-
16, ...	-	-	-	-	-	+	-	-	-	-
17, ...	-	3	-	0	-	-	-	-	-	-
18, ...	-	-	-	-	-	+	-	-	-	-
19, ...	-	-	-	-	-	-	-	-	-	-
20, ...	-	-	-	-	-	-	-	-	-	-
21, ...	-	-	-	-	-	0	-	-	-	-
22, ...	-	-	-	-	-	-	-	-	-	-
23, ...	-	-	-	-	-	0	-	-	-	-

* Bottle broken.

4. *Natural Freezing.*

Seventeen experiments upon the elimination of B. coli and B. typhosus by the formation of ice resulted as follows; the ice being examined soon after its formation: —

TABLE NO. 13.— *Showing Percentage Reduction of the Numbers of B. Coli and B. Typhosus in Ice by Natural Freezing.*

B. COLI.		B. COLI.		B. TYPHOSUS.		B. TYPHOSUS.	
Number of Germs in Water.	Per Cent. removed by Freezing.	Number of Germs in Water.	Per Cent. removed by Freezing.	Number of Germs in Water.	Per Cent. removed by Freezing.	Number of Germs in Water.	Per Cent. removed by Freezing.
196	100	47	79	7	100	285	98
21	62	29	90	600	100	106	92
74	99	16	56	500	100	69	90
1,885	30	-	-	21	95	6	18
1,115	91	-	-	2,100	97	-	-

5. *Elimination by Complete Freezing.*

When a small body of water is submitted to cold so that all the water is frozen in the course of a few minutes, the bacteria are subjected, not only to the action of the cold, but also to considerable stress or compression, due to the expansion of the water in the act of freezing.

About 50 per cent. of the B. coli and 75 per cent. of the B. typhosus were removed by fifteen minutes of complete freezing; at the end of one hour about 95 per cent. of the B. coli and 97 per cent. of the B. typhosus had disappeared from the ice, and in from three to seven hours over 99 per cent. of both germs were eliminated. The complete results of two experiments with each germ are given in Table No. 14.

TABLE No. 14.— *Showing Reduction in Numbers of B. Coli and B. Typhosus, in Ice during the First Few Hours of Freezing.*

TIME.	B COLI.			B. TYPHOSUS.		
	I.	II.	Average Per Cent. Reduction.	I.	II.	Average Per Cent. Reduction.
Start,	70,800	57,400	-	12,900	11,400	-
15 minutes,	51,200	14,200	49	3,400	2,300	77
30 minutes,	12,400	6,600	85	3,300	2,900	75
45 minutes,	8,200	7,500	88	3,300	322	85
1 hour,	3,300	2,600	95.3	582	122	97
1¼ hours,	4,000	3,200	94.3	722	145	96
1½ hours,	5,000	2,900	94	89	40	99.4
1¾ hours,	5,400	3,500	93	-	-	-
2 hours,	4,300	2,400	95	387	6	98.4
2½ hours,	5,800	1,300	94.3	2	1	99.9
3 hours,	785	705	99	3	2	99.9
4 hours,	600	560	99	7	2	99.9
5 hours,	4,200	1,800	95.3	4	2	99.9
6 hours,	501	155	99.5	6	2	99.9
7 hours,	395	283	99.5	7	3	99.9
24 hours,	-	-	-	1	1	100.0

6. *Viability in Ice.*

While probably a greater percentage of bacteria are destroyed during the first few hours of freezing than would be the case by an exposure of the fluid culture to a like degree of cold, the fact remains that there are a few organisms which, having once resisted freezing, will live for a considerable length of time in ice. The increased viability in ice over that in water is undoubtedly due to the fact that in ice all germs are rendered torpid, whereas in water some species of bacteria are able to live and complete the cycle of their existence at very low temperatures, and these would, of course, tend to overgrow and kill out the typhoid germs and colon bacilli, which are unable to multiply under these circumstances.

The elimination of the few germs remaining after the first twenty-four hours of freezing appears to be difficult. The results of the experiments have varied very considerably. In one case all but a few of the typhoid germs were destroyed by two hours' freezing, as shown in the preceding table. In another case this organism was not found in 1 cubic centimeter after the fourth day, while in another case it was found present in small numbers in that volume on the twenty-fourth day. With B. coli in one case the germs could not be detected in 1 cubic centimeter after the fourth day, while in another experiment it was found when examining that volume after one hundred and thirty-five days.

If larger volumes of ice be examined the germs will be found alive for longer periods, B. typhosus being found alive in two experiments after two hundred and eighty days' exposure in the frozen condition. After long exposure to cold by retention in the ice the morphological and cultural characteristics of both of these cultures of B. coli and B. typhosus became so changed that we should never have recognized the organisms as the ones with which the experiments were started unless we had known positively that we were dealing with pure cultures. Both germs reverted to a common type, entirely different from the stock culture, and even by the most extended courses of cultivation on the laboratory media we were unable to bring these cultures back to the original type. The results of these experiments on long-continued storage of cultures in frozen condition is shown in Table No. 15.

TABLE NO. 15. — *Showing Viability of B. Coli and B. Typhosus in Ice.*

DAYS.	B. COLI.							B. TYPHOSUS.					
	70			163	66			143			145		
	1 c. c.	10 c. c.	100 c. c.	1 c. c.	1 c. c.	10 c. c	100 c. c.	1 c. c.	10 c. c.	100 c. c.	1 c. c.	10 c. c.	100 c. c.
Start, .	11,600	-	1	6,900	5,000	1	-	25,700	-	-	43,800	-	-
1, .	4,000	+	+	4,000	4,800	+	+	50	+	+	2,760	+	+
2, .	3	+	+	2,100	4	+	+	11	+	+	53	+	+
3, .	2	+	+	420	14	+	+	+	+	+	176	+	+
4, .	2	+	+	386	13	+	+	+	+	+	204	+	+
5, .	-	-	-	-	-	-	-	0	+	+	21	+	+
6, .	0	+	+	302	61	+	+	0	+	+	9	+	+
7, .	0	+	+	110	0	+	+	0	+	+	2,084	+	+
8, .	0	0	+	133	1	+	+	0	+	+	115	+	+
10, .	-	-	-	70	1	+	+	0	+	+	34	+	+
11, .	0	0	+	53	-	-	-	0	+	+	7	+	+
13, .	-	-	-	206	2	+	+	0	+	+	73	+	+
14, .	-	-	-	161	20	+	+	0	+	+	25	+	+
15, .	-	-	-	35	3	+	+	0	+	+	23	+	+
17, .	-	-	-	19	2	+	+	0	+	+	7	+	+
20, .	0	0	+	221	2	+	+	0	+	+	17	+	+
22, .	0	0	+	63	3	+	+	-	-	-	-	-	-
24, .	-	-	-	-	5	+	+	0	+	+	7	+	+
27, .	-	-	-	9	0	+	+	-	-	-	-	-	-
31, .	0	0	+	75	0	+	+	0	+	+	0	+	+
36, .	-	-	-	341	0	+	+	-	-	-	-	-	-
45, .	-	-	-	534	0	+	+	0	+	+	0	+	+
55, .	0	0	+	504	0	+	+	0	+	+	0	+	+
65, .	0	0	+	45	0	0	+	0	+	+	0	+	+
75, .	-*	-	-	71	0	0	+	0	+	+	0	+	+
85, .	-	-	-	81	-*	-	-	-	-	-	-	-	-
95, .	-	-	-	282	-	-	-	0	+	+	0	+	+
105, .	-	-	-	19	-	-	-	0	+	+	0	+	+
115, .	-	-	-	31	-	-	-	0	+	+	0	+	+
125, .	-	-	-	4	-	-	-	0	+	+	0	+	+
135, .	-	-	-	70	-	-	-	0	+	+	0	+	+
150, .	-	-	-	-*	-	-	-	0	+	+	0	+	+
165, .	-	-	-	-	-	-	-	0	+	+	0	+	+
195, .	-	-	-	-	-	-	-	0	+	+	0	+	+
225, .	-	-	-	-	-	-	-	0	0	+	0	0	+
245, .	-	-	-	-	-	-	-	0	0	+	0	0	+
280, .	-	-	-	-	-	-	-	0	0	+	0	0	+
310, .	-	-	-	-	-	-	-	0	0	0	0	0	0
315, .	-	-	-	-	-	-	-	0	0	0	0	0	0

* Experiment incomplete.

7. *Resistance to Heat.*

While the thermal death point of both typhoid and B. coli have been determined by various observers, very little literature exists as to the diminution in numbers of the two organisms when submitted to various degrees of heat for short periods of time. In our experiments, equal volumes of water dilutions of virulent broth cultures were placed in small tubes, these being carefully selected for uniformity as to bore and thickness of glass. These tubes were then submitted, one at a time, to a different temperature for a period of five minutes, after which one cubic centimeter of the water was plated out immediately, and after incubation at body temperature for twenty-four hours, the number of organisms present in the sample were counted. The temperatures ranged from 30° C. to 100° C., tests being made at intervals of five degrees. Thermometer readings, with the thermometer inside the tube, showed that the contents of the tube reached the temperature of the bath in about one-half minute, the five-minute exposure, however, being reckoned from the time of immersion. The results of the different tests agreed fairly well, both as regards duplicate determinations with the same species and as comparisons of the two species.

From 30° to 45° C. both species diminish gradually in numbers, the percentage reduction being greater for typhoid than for B. coli, about 88 per cent. of the former and 30 per cent. of the latter being eliminated at 45°. At 50° there was only a slight additional decrease in the numbers of typhoid germs, the B. coli being all destroyed with the exception of a few stray individuals. At 55° all of the typhoid germs, with the exception of some half a dozen individuals, were destroyed. At 55°, 60°, 65°, 70° and 80° a few individuals of each species were found to survive. At 85° both cultures were completely sterilized. The results of two experiments with typhoid and two with B. coli are shown in Table No. 16.

TABLE NO. 16. — *Showing the Number of Germs per Cubic Centimeter in Water Cultures of B. Coli and B. Typhosus after Five Minutes' Exposure to Various Temperatures.*

TEMPERATURE (DEGREES C.).	B. COLI.		B. TYPHOSUS.	
	I.	II.	I.	II.
20,	48,200	51,800	5,300	5,500
30,	46,000	47,400	6,100	5,500
35,	39,000	39,400	5,200	4,400
40,	25,500	26,300	8,000	2,400
45,	12,100	15,900	9,700	7,700
50,	27	33	4,900	5,300
55,	3	3	3	1
60,	5	6	0	0
65,	1	2	1	0
70,	3	2	6	8
75,	3	3	3	1
80,	0	0	2	0
85,	0	0	0	0
90,	0	0	0	0
95,	0	0	0	0
100,	0	0	0	0

8. *Resistance to Sunlight.*

While it is generally known that many bacteria are destroyed by exposure to sunlight, very little, if any, data exist concerning the exact quantitative reduction in the numbers of the germs during their exposure to the sunlight. A number of experiments along this line have been made at Lawrence, the same cultures of typhoid and B. coli being used as were used in the experiments heretofore mentioned.

In two experiments, each with typhoid and B. coli, water dilutions were made from fresh cultures of the germs, 1 cubic centimeter of this water being placed in Petri dishes in the sun for definite periods. After exposure the water in the plates was mixed with agar and all plates were incubated twenty-four hours at 38°, after which the number of colonies was counted. In one experiment, No. 26, the water dilution of typhoid was mixed with melted agar and plates made as usual. After the agar had set, these plates were then exposed to the sunlight. In one experiment with B. coli, No. 81, the water culture was not exposed to the sunlight in plates, but the exposure was made in a clear, white glass bottle of the Blake pattern, holding 100 cubic centimeters, samples being taken from this at the proper intervals and plated as usual.

In all cases control cultures were made under exactly the same conditions as were the cultures exposed, these, however, being protected from the sunlight by a heavy, opaque cloth, or some similar material. The temperature of these cultures was, of course, considerably lower than was the temperature in the sun. The numbers of bacteria in the controls showed the usual variation to be expected under the circumstances, usually a slight reduction in numbers being noted during two or three hours' standing, although in one instance the numbers increased quite materially. The data of these control cultures are not shown in the accompanying tables.

The brightness of the sun also varied considerably, and attempts were made to measure the amount of light by photographic means, but these measurements were unsatisfactory, and the data are not included here.

With typhoid, from 95 to 99 per cent. of all the germs were destroyed by ten to fifteen minutes' exposure to direct sunlight. A few germs may resist the sunlight for a somewhat longer time; usually, however, all the germs were destroyed by three or more hours' exposure to bright sunlight. The results of the experiments with typhoid are shown in the following tables, in Table No. 17, experiments 24 and 25 being the ones in which the water cultures were exposed to the sunlight. Experiment No. 26, Table No. 18, being the one in which the agar plates were exposed.

TABLE NO. 17.— *Showing Elimination of Typhoid Germs in Water on Exposure to Sunlight.*

EXPOSURE.	EXPERIMENT 24.			EXPERIMENT 25.		
	Bacteria.		Average.	Bacteria.		Average.
Start,	698	734	716	592	532	562
15 minutes,	66	4	35	13	5	9
30 minutes,	17	1	9	4	4	4
45 minutes,	0	1	1	3	0	2
1 hour,	6	2	4	21	5	13
1½ hours,	2	0	1	5	3	4
2 hours,	0	0	0	4	3	4
4 hours,	3	1	2	0	0	0
6 hours,	0	0	0	0	0	0

TABLE NO. 18.— *Showing Elimination of Typhoid Germs in Agar Plates on Exposure to Sunlight.*

EXPOSURE.	Temperature.	EXPERIMENT 26.		
		Bacteria.		Average.
Start,	-	608	642	625
10 minutes,	91° F.	2	3	3
20 minutes,	83	7	2	5
30 minutes,	81	0	0	0
40 minutes,	83	0	0	0
50 minutes,	83	0	0	0
1 hour,	78	1	0	1
1 hour, 10 minutes,	74	0	0	0
1 hour, 20 minutes,	71	0	0	0
1 hour, 30 minutes,	69	0	0	0
1 hour, 40 minutes,	68	0	0	0
1 hour, 50 minutes,	71	0	0	0
2 hours,	68	0	0	0

With B. coli the results have been somewhat more variable, probably due to more changeable conditions. In one experiment, No. 78, something over 80 per cent. of the germs were destroyed by fifteen minutes' exposure, all being destroyed after four hours. The results of this experiment were undoubtedly influenced greatly by clouds in the sky, so that at times the sunlight was not very bright, after about two and one-half hours the sun being entirely overcast. In experiment No. 79, about 96 per cent. of the germs were eliminated at the end of fifteen minutes and after thirty minutes all of the germs were destroyed. In these two experiments the water cultures were exposed in plates, the results being shown in Table No. 19.

TABLE NO. 19.— *Showing Elimination of B. Coli in Water Cultures on Exposure to Sunlight.*

EXPOSURE.	EXPERIMENT 78.				EXPERIMENT 79.			
	Temperature.	Bacteria per Cubic Centimeter.		Average.	Temperature.	Bacteria per Cubic Centimeter.		Average.
Start,	78	70,000	72,800	71,400	-	445,400	824,300	634,850
15 minutes,	78	6,564	16,166	12,365	106	19,100	31,800	25,400
30 minutes,	80	4,473	2,663	3,568	107	0	0	0
45 minutes,	80	2,130	0	1,065	110	0	0	0
1 hour,	80	590	0	295	100	0	0	0
1½ hours,	82	2,130	93	1,111	108	0	0	0
2 hours,	62	10	70	40	105	0	0	0
3 hours,	-	-	-	-	100	0	0	0
4 hours,	61	0	0	0	78	0	0	0

In experiment No. 81 the water was exposed in bottles. In this case about 98 per cent. of the germs were destroyed after fifteen minutes, the cultures varying somewhat. The germs persisted in the water in considerable numbers for two hours and in small numbers up to four hours, after five hours the sample being completely sterilized. The results of this experiment are shown in Table No. 20.

TABLE NO. 20.— *Showing Change in Numbers of B. Coli in Water in Bulk on Exposure to Sunlight.*

EXPOSURE.	Temperature.	EXPERIMENT 81.		
		Bacteria per Cubic Centimeter.		Average.
Start,	94	2,360,000	1,620,000	1,990,000
15 minutes,	94	30,000	43,200	36,600
30 minutes,	92	85,300	22,000	53,650
45 minutes,	92	44,000	55,000	49,500
1 hour,	94	53,700	45,300	49,500
1½ hours,	96	35,800	34,100	34,950
2 hours,	109	57,400	76,400	66,900
3 hours,	95	450	1,172	786
4 hours,	102	3	5	4
5 hours,	76	0	0	0

Summary and Conclusions.

The principal types of bacteria used as indices of pollution are the colon type, the sporogenes, sewage streptococcus type, and occasionally the aerogenes and the chologenes types. The colon type has received the most study; it is widely distributed in nature and since it is the most numerous of these types in normal sewage, it is of the most value as a positive indication of sewage pollution. The streptococcus type and sporogenes types have not yet received the study necessary to determine their value as indications of pollution. The aerogenes and chologenes types have no specific value, but are included by the tests applied in some laboratories under the colon type.

In the filtration of a polluted water, such as that of the Merrimack River, bacterial tests are, as is well known, of more value than chemical analyses. The filtered water may be changed but little from the raw water by filtration, as far as chemical analyses can determine, and yet a source of danger be absolutely removed, as shown or strongly indicated by bacterial tests. Long-continued comparisons of the bacterial examinations, as applied to raw and filtered waters, have shown that the B. coli test is a more delicate indication of filter efficiency, when filtering water as polluted as that of the Merrimack River water, than tests of the total number of bacteria present in the filtered and unfiltered waters. Disturbing factors in filtration shown slightly or not at all by ordinary bacterial counts and comparisons are often shown strongly by B. coli tests.

In the examination of spring waters the degree of purity of samples, collected in a careful and proper manner from properly guarded springs, is almost absolutely shown by chemical analysis. B. coli was found in only six of all the spring water samples examined that were collected directly from the springs by employees of the Board, and in four of these waters both inspection of the surroundings of the spring and chemical analysis would alone have condemned the waters. In one case the entrance of B. coli occurred, and pollution was not otherwise shown by either inspection or chemical analysis. This accidental pollution was evidently only applicable to this sample, however, and not to the general flow of water from this spring. It is evident, of course, that however pure the water might be as coming from the ground, accidental contamination from the person collecting or bottling the water might introduce B. coli into the spring itself and this contamination not be shown by chemical analysis, and this was probably the case in this instance.

In the samples of spring waters, as sold upon the market, the chemical analyses did not and could not reveal such slight accidental contamination as might introduce B. coli, shown by the detection of this germ, and this contamination might be of considerable moment. The determinations of numbers of bacteria in these samples were of little significance, as the waters had been bottled for indefinite periods of time, with a plentiful chance for the increase of the bacteria normally present in them when drawn from the springs.

In the examination of ground waters from driven wells, comparisons of the chemical, bacterial and B. coli analyses show that in all of 128 samples quoted in this article, the chemical and bacterial, including B. coli, examinations were in agreement. In the one instance, out of the 128 examinations recorded, in which B. coli was found in a tubular well water, chemical analyses also showed the water to be of a poor quality. In one instance, as has already been stated, accidental pollution of driven well water, to such an extent that the health of the people using this water was seriously affected, as shown by many cases of typhoid fever, was not indicated by either chemical or bacterial tests, but was indicated by the presence of B. coli in a water that had never before given positive tests for this germ, and in which subsequent tests, after the passing away of this pollution, again gave negative results.

Eighteen samples of water from filter galleries showed no evidence of pollution by B. coli tests in 1 and 100 cubic centimeters.

The complete analyses of samples from a large number of domestic wells show that polluted waters that might become unfit for consumption at any moment are more plainly indicated by single chemical analyses than by single determinations of B. coli. The presence of B. coli at the time of examination may indicate actual danger to health and its absence even in the most polluted of these waters — chemically — may indicate lack of imminent danger, but the chemical analyses are certainly the more decisive.

The results of the examination of samples from ponds and lakes show with considerable clearness that in the examination of surface waters from inhabited localities, the question of obtaining positive tests for B. coli is only one of taking a sufficient volume of water for the test. They also show with considerable clearness that the degree of contamination of these waters varies inversely as the volume required to give a positive test for B. coli.

The number of B. coli in a river as polluted as the Merrimack varies in inverse ratio with the dilution of the entering sewage by the river water, and is affected by the temperature, the numbers of B. coli being larger during the warm weather than during cold weather. In effluents from water filters the effect upon filter efficiency of dilution of the raw water in winter is less marked than the effect of high temperature in summer, the work of a filter in warm weather, when biological processes are active, being far more satisfactory than during cold weather.

The number of B. coli in a water is reduced quite appreciably by storage of the water.

In the examination of shell-fish from suspected sources, the determination of fecal bacteria, such as the colon bacillus, is of considerable importance, as showing the purity or pollution of these sources.

As an indication of the presence of B. coli the presumptive test, so called, has, judging from our own work, little value unless supported by subsequent confirmatory tests. In a few instances, where one is dealing with a given kind of water continuously, the observer may become so expert as to be able to judge the presence of B. coli by the presumptive test, followed by the litmus lactose agar plate and the appearance on the agar streak, but if the classes of water are varied, even the most expert observer will fall into serious errors if he depends on those tests alone. The presumptive test includes at least 58 well-described species of bacteria, of which 12 would be included in the colon type, as determined at Lawrence, 7 species are of the aerogenes type, 3 species are of the chologenes type and 13 species are not sufficiently well described to identify them with or exclude them from the three preceding groups. Besides these, there are 23 species which would show positive results by the presumptive test alone, which would never be included in the fecal group.

Results of examinations for B. coli in different volumes of water show that tests in both 1 and 100 cubic centimeters are of value, the tests in the larger volumes being confirmatory of the tests in the smaller volume. In cases where a considerable number of samples are taken from the same source, the tests in the larger volume frequently give more information as to the quality of the water than do the tests in 1 cubic centimeter.

Outbreaks of typhoid fever coincident with the finding of B. coli in normally pure waters, *i. e.*, in water known to be safe under ordinary conditions but becoming polluted by the entrance of polluted water, have occurred in at least three instances within the observation of the writers, where the danger was not indicated by chemical tests or by a significant increase in the numbers of bacteria beyond the usual limits of variation for waters of their class.

Comparative tests for the relative viability of B. typhosus and B. coli show us that there is a very great similarity between the length of life of the two germs under a great variety of conditions. Both germs appear to follow the general laws of the removal of bacteria by sand filters, a somewhat greater viability being noted in the case of B. coli than of B. typhosus. Most organisms of both types are destroyed quite rapidly by the effect of cold either in fluid culture or when frozen in ice. When caught in ice, both germs will live, in slowly reducing numbers, for a considerable length of time, and under these conditions the morphological and cultural characteristics of the species may lose their identity and appear to merge into a common type which there are reasons to believe would be non-pathogenic. When subjected to heat, both species appear to follow about the same rule, the majority of the typhoid germs being destroyed by five minutes' exposure to a temperature of 45° C. and nearly all of the B. coli being destroyed by five minutes at 50° C., a few individuals of each surviving exposure to temperatures up to and including 80° C. The thermal death point appears to lie between 80° and 85° C., a point somewhat higher than has usually been set for these species. Both species are rapidly destroyed by sunlight, an exposure of thirty minutes to one hour usually being sufficient to sterilize the culture when spread out in a thin layer. Both show the same phenomena noted in other experiments, that while the larger numbers of germs are destroyed in a very short time, a few individuals nearly always appear to be more resistant to unfavorable conditions.

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REPORT UPON THE

EXAMINATIONS OF THE OUTLETS OF SEWERS

AND THE

EFFECT OF SEWAGE DISPOSAL IN MASSACHUSETTS.

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Office of State Board of Health, State House,
Boston, Aug. 20, 1903.

To Hiram F. Mills, A.M., C.E., *Chairman of Committee on Water Supply and Sewerage of the State Board of Health.*

Sir: — Herewith is submitted a report upon the results of examinations of the main outlets of sewers and drainage of the cities and towns of the Commonwealth and the effect of sewage disposal made during the year 1902 under the provisions of chapter 104 of the Acts of the year 1901.

REPORT.

The first sewers in the State were built in the city of Boston, probably more than two hundred years ago. The early sewers were evidently for the most part drains for removing ground water or storm water and sink drainage, and were built or owned by private individuals or associations of citizens living on a single street or in a small district. It appears from records and reports as to the sewerage of Boston that about the year 1823 the city took control of the sewers, but that for several years after that time fæcal matter was rigidly excluded from them. In 1857 only about 6,500 water-closets were connected with the sewers, and in 1885 the number connected was about 100,000. At the present time it is about 160,000.

The history of the growth of sewerage in many of the other large cities and towns in the State has been similar to that of the Boston system. The sewers were at first intended to serve chiefly as drains, for the drainage of streets, cellars and wet places, or for the removal of standing water, and were subsequently used as places of disposal for sink wastes.

The common, and practically the only, method of disposing of drainage and of such sewage as might be mingled therewith before public water supplies came into general use was to discharge it into the nearest body of water, and this method of disposal probably did not create seriously objectionable conditions when the quantity of sewage mingled with the drainage was small, and consisted chiefly of sink wastes; but, after the introduction of public water supplies, water-closets and other water fixtures rapidly came into general use, the amount of house sewage and polluted water requiring disposal greatly increased, and nuisances were created at the outlets of the drains. Moreover, with the use of the drains as sewers more careful methods of construction and maintenance became necessary, in order to prevent foul odors and other objectionable conditions arising from the drains themselves.

The plan of keeping sewage separate from storm and drainage water, now known as the "separate" system of sewerage, in contrast with the earlier plan of receiving all sewage and drainage into the same pipes, known as the "combined" system of sewerage, has now been in use for about twenty years. At the present time combined systems of sewerage exist mainly in the larger cities and towns, in which sewers were gradually developed from drains in the manner indicated, or in which sewerage systems were begun twenty or more years ago; while in towns in which sewerage systems have been constructed within the last fifteen or twenty years the separate system has been employed in nearly all cases. Cities and towns having combined systems of sewers generally, however, until recently, have continued to employ this system in making extensions; but the further extension of the combined system of sewers has been practically discontinued in many of the places in which it has hitherto been exclusively used, and the separate system is now used in the sewerage of new areas. In some places having combined systems the work of separating the sewage from the storm water — that is, of providing a separate system of sewers to replace a combined system — has been begun.

In this report, when reference is made to combined systems of sewers it is to be understood to mean a system which receives both sewage and the surface water from streets and other areas, together with cellar or other drainage from the ground. Where the separate system of sewers is referred to it is to be understood that the sewers of such systems receive sewage and manufacturing wastes, but do not receive storm water or ground drainage, except such ground water as leaks into the sewers from defective joints and connections, — which, it may be said in passing, may amount to nearly as much, and in extreme cases to more, than the actual quantity of sewage. Drainage is to be understood to mean the water flowing in drains provided for the reception of water from streets, roofs, etc., and from cellars or wet grounds, and other clean water, such as waste water used for cooling, etc., in some mechanical or manufacturing processes, which is not polluted.

In presenting the results of the examinations it has been found necessary to divide the outlets into two general classes: (1) those which discharge into the sea or into harbors or tidal estuaries along the sea coast;

and (2) outlets into rivers and other inland waters; since those in the former class are largely independent of each other, while in the case of river outlets it has been essential to consider also the condition of the rivers, some of which receive sewage from many outlets in different cities and towns.

PART I.—SEWER OUTLETS INTO THE SEA OR INTO HARBORS OR BAYS ALONG THE SEA COAST.

The total population in the cities and towns discharging sewage into the sea amounted by the census of 1900 to 1,392,721, almost one-half the total population of the State.

The outlets into the sea were examined last year with special reference to the effect of such outlets upon flats or waters from which shell-fish are taken for food; and the results of the investigations relating to the pollution of shell-fish by sewer outlets were presented in last year's report, and will not be referred to in the present report. Further investigations along these lines are now being made, but additional results of importance are not yet available.

Each outlet into the sea has been examined with reference to the existence of offensive odors or other objectionable conditions, and in the case of some of the more important outlets observations of the movement of the sewage have been made, and samples of the harbor waters have been analyzed to determine the extent to which such waters are affected by the sewage. The results of the investigations of outlets into the sea or into harbors or tidal estuaries along the sea coast will be presented in alphabetical order under the names of the cities and towns controlling the various outlets, except that the outlets of the city of Boston and the metropolitan districts will be first presented.

The following table contains a list of the cities and towns having outlets into the sea which have been examined during the year:—

CITY, TOWN OR DISTRICT.	Population in **1900.**	CITY, TOWN OR DISTRICT.	Population in **1900.**
Boston main drainage and south metropolitan sewerage districts.	612,371	Lynn,	68,513
North metropolitan sewerage district,	422,625	Nahant,	1,152
Beverly,	13,884	New Bedford,	62,442
Fairhaven,	3,567	Newburyport,	14,478
Fall River,	104,863	Plymouth,	9,592
Gloucester,	26,121	Revere,	10,395
Hingham,	5,059	Salem,	35,956
Hull,	1,703	Total,	1,392,721

BOSTON MAIN DRAINAGE AND SOUTH METROPOLITAN SEWERAGE DISTRICTS.

These districts include the following cities, towns and districts: —

City, Town or District.	Population in 1900.	Kind of Sewerage System.
Boston (proper),	167,257	Combined.
South Boston (district of Boston),	67,809	Combined.
Roxbury (district of Boston),	105,393	Combined and separate.
Dorchester (district of Boston),	77,483	Combined and separate.
West Roxbury (district of Boston),	37,263	Combined and separate.
Watertown,	9,706	Separate.
Waltham,	23,481	Separate.
Newton,	33,587	Separate.
Brighton (district of Boston),	19,279	Combined and separate.
Brookline,	19,935	Combined and separate.
Dedham,	7,457	Separate.
Hyde Park,	13,244	Separate.
Milton,	6,578	Separate.
Quincy,	23,899	Separate.
Total,	612,371	

Description of Systems.

Boston Main Drainage District. — The sewage of the city of Boston previous to the year 1884 was discharged into the waters about the city at a great many outlets. The great nuisances resulting at many of these outlets led to the adoption in 1876 of a plan for the collection and disposal of the sewage at an outlet into the sea at Moon Island in the southerly portion of Boston harbor, a point remote from the thickly populated portions of the city; and the necessary sewers and other works constituting the so-called main drainage system of the city were completed at the beginning of 1884. By means of these works the dry-weather flow of sewage of the main portions of the city and of the districts of Roxbury, Dorchester and West Roxbury since that time has been conveyed to the Moon Island outlet. The Brighton, Charlestown and East Boston sections of the city were not included in this system.

Practically all of the sewers of the Boston main drainage district are constructed on the combined plan, and, since it would have been impracticable to construct works of sufficient size to take all of the flow of the various sewers at times when the flow is increased by heavy rains, the system was designed to intercept and remove all the sewage flowing in the sewers in dry weather and the sewage and rain water at times of light rain, allowing the excess of flow at times of heavy rain or when snow is melting rapidly to discharge at the original outlets. There is a great number (about 100) of these storm overflow outlets from which dilute sewage is discharged at intervals into the waters about the city.

South Metropolitan District. — In 1892 the Charles River valley metropolitan sewer was completed and connected with the Boston main drainage system; and since that time the sewage of Waltham, Watertown, Newton, Brookline and the Brighton district of Boston has been discharged at the outlet at Moon Island in Boston harbor, through this sewer and the Boston main drainage works. The sewers of Watertown, Waltham, Newton and a part of those of Brighton and Brookline are constructed on the separate plan; and there are no local outlets for sewers in the first three of these places, but in the last two there are storm overflow outlets from combined systems which discharge dilute sewage at intervals into the Charles River and some of its tributaries.

In 1895 the Neponset valley metropolitan sewer was completed and connected with the Boston main drainage system, and sewage from the towns of Dedham, Hyde Park and Milton, together with sewage from portions of the town of Brookline and of the West Roxbury and Dorchester districts of Boston, is conveyed to the outlet at Moon Island through the Neponset valley sewer and the Boston main drainage system. The sewers in the towns and districts connected with the Neponset valley sewer, excepting a small area in Dorchester, are built upon the separate plan, and there are no local outlets in the fresh water portion of the Charles or Neponset rivers from the sewers of this district.

In 1899 works were completed by which the sewage of the city of Quincy is pumped into the Boston main drainage sewer at Squantum near Moon Island, and since that time sewage from the city of Quincy has found an outlet through the Moon Island works of the Boston main drainage system. The sewers of the city of Quincy are built upon the separate plan, and there are no local sewer outlets, though relief valves have been placed on main sewers near the pumping station, by means of which sewage could be discharged into local water courses at a few places in case of accident to the pumps or other emergency.

In 1899 the south metropolitan sewerage system was created, which includes the territory formerly tributary to the Charles River valley sewer and the Neponset valley sewer, with other areas in the southerly parts of the city of Boston; and provision was made for the construction of a large main sewer to receive the sewage of the two metropolitan sewers, the sewage of the Quincy sewerage system and of areas in the valley of Stony Brook in the West Roxbury and Dorchester districts of the city of Boston. The outlet of this sewer is to be located near Peddock's Island in the southeasterly part of Boston harbor, and this sewer is now approaching completion. Upon the completion of this sewer much of the sewage from cities, towns and districts which now finds an outlet at Moon Island will be diverted to the new outlet.

Description of Sewer Outlets.

The Moon Island outlet was very thoroughly examined in 1899 and 1900, and the conditions about this outlet are described in the report of the State Board of Health upon the "Discharge of Sewage into Boston Harbor," in the latter year.

The sewage of the Boston main drainage and south metropolitan sewerage districts is all pumped to collecting reservoirs at Moon Island, from which it is discharged into the sea upon the outgoing tide. This sewage when discharged covers a large area between Moon Island and Long Island, and is offensive to those sailing through this part of the harbor in boats. Its presence on the surface of the water can be detected easterly as far as Rainsford Island, by the greasy scum, or "sleek," upon the water, but the sewage does not approach the shore of the main land at any point.

The conditions about the Moon Island outlet are not seriously objectionable at the present time; and, while deposits of matters from the sewage have taken place along the shore near the outlet in the past during a time before the recent enlargement of the reservoirs, when it was necessary to discharge sewage at unfavorable stages of the tide, the conditions causing these deposits have now been removed, and further deposits do not appear to be taking place. The quantity of sewage now conveyed to this outlet is rapidly nearing the capacity of the works and the capacity of the tidal currents into which it is discharged to quickly remove and dispose of it. Upon the completion of the high-level sewer now under construction much of the sewage discharged at this outlet will, as already stated, be discharged at the proposed new outlet at Peddock's Island.

Other Outlets for Sewage in the Boston Main Drainage and South Metropolitan Sewerage Districts.

The storm overflow outlets from which the excess of mingled sewage and storm water, above the capacity of the metropolitan and main drainage sewers, is discharged into waters about the city at times of rain, do not appear to cause serious objection at the present time, except in cases where such outlets discharge into small water courses. A large number of such outlets discharge into Stony Brook, and the storm overflows into this stream contribute to the nuisance in the Back Bay Fens, through which Stony Brook flows.

The most serious nuisance existing at the present time in the Boston main drainage or south metropolitan sewerage districts by reason of the disposal of sewage is in the basin of the Back Bay Fens in the city of Boston. Investigation shows that, while the water of this stream is clean and unobjectionable to sight or smell at its entrance to a covered channel at Jamaica Plain, it is filthy in appearance and has an offensive odor at the point from which it emerges from the covered channel at Huntington Avenue, through which it flows in its course below Jamaica Plain. It is evident that much sewage is discharged into this covered channel at all times, greatly polluting the brook, and it is to this sewage that the nuisance in the Back Bay Fens is chiefly due. This nuisance could be prevented by removing all connections through which sewage or objectionable manufacturing waste is discharged into the Stony Brook channel, and discharging this sewage or waste into local sewers. If this channel is to continue to be used as a sewer, it should be treated as such, and the dry-weather flow discharged into the metropolitan or main drainage sewers.

There is also an old Stony Brook channel passing through Roxbury which discharges on the northerly side of Beacon Street at the edge of the Charles River. This stream receives, evidently, much sewage and considerable foul drainage, and constitutes, in effect, a separate sewer outlet. The outlet is so located that it is partially exposed at times of low water, when an objectionable odor issues from it. Plans have been prepared by the street department of Boston for rebuilding this channel, eliminating the sewage and using it for drainage only. Unless this change is made, this outlet should be treated as are other outlets for sewage, and made a part of the general sewerage system.

There are several cases in which overflows from sewers discharge upon flats exposed at low water, which may create objectionable conditions at times, but the investigations have not shown the existence of serious nuisances at such outlets at present.

THE NORTH METROPOLITAN SEWERAGE DISTRICT.

The cities, towns and districts included in the north metropolitan sewerage district are the following: —

City, Town or District.	Population in 1900.	Kind of Sewerage System.
East Boston (district of Boston),	45,756	Combined.
Charlestown (district of Boston),	40,652	Combined.
Somerville,	61,643	Combined and separate.
Chelsea,	34,072	Combined and separate.
Everett,	24,336	Combined and separate.
Cambridge,	91,886	Combined and separate.
Malden,	33,664	Separate.
Medford,	18,244	Separate.
Winthrop,	6,058	Separate.
Melrose,	12,962	Separate.
Arlington,	8,603	Separate.
Belmont,	3,929	Separate.
Lexington,	3,831	Separate.
Winchester,	7,248	Separate.
Woburn,	14,254	Separate.
Stoneham,	6,197	Separate.
Wakefield,	9,290	Separate.
Total,	422,625	

The north metropolitan sewerage district was established in 1889, and the works were completed and first operated in 1895. Sewerage systems existed in Cambridge, Somerville, Chelsea, Charlestown and East Boston, and in some other parts of the district, for many years before the metropolitan system was built; and the sewage from the places mentioned was discharged at numerous outlets into the Charles and Mystic rivers and the harbor or their tributaries.

In the case of this system, as in that of the Boston main drainage system, it was impracticable to build sewers of sufficient size to remove all the sewage and storm water from the areas served by combined systems, and provision was made for taking all of the flow of sewage in dry weather and a portion of the excess of flow caused by rain in wet weather, allowing the further excess beyond the capacity of the works to discharge at the old sewer outlets, or at outlets provided for the purpose. In towns in the upper part of the district served by separate systems of sewers such outlets are unnecessary, and local outlets do not exist.

In East Boston and Chelsea there are several outlets at which sewage is discharged continuously.

DESCRIPTION OF MAIN OUTLET OF THE NORTH METROPOLITAN SEWERAGE SYSTEM.

The main sewer outlet of the north metropolitan sewerage system is located near Deer Island Light, on the outer end of the Deer Island bar, and on the northerly side of the main ship channel of Boston harbor, where the sewage discharges at about the level of low tide. The sewage of this district is not collected in reservoirs, but is discharged continuously at all stages of the tide.

During the outgoing tide the sewage flows to sea in a comparatively narrow stream, less than half a mile in width at the widest place, and disappears in comparatively calm weather in a distance of a little over one and a quarter miles. On the incoming tide the sewage flows in a similar stream in a westerly, and, toward the latter end of the incoming tide, in a northwesterly, direction, and near the time of high tide covers a somewhat larger area than on the outgoing tide. At times of strong wind sewage from this outlet disappears at very much less distances from the outlet than those described above.

This outlet was very thoroughly examined in the years 1899 and 1900, and the results of the examinations are presented in the report upon the "Discharge of Sewage into Boston Harbor," already referred to.

It does not appear that any material change has taken place since that time in the conditions about this outlet, judging from the more recent examinations.

The sewage discharged at Deer Island spreads over a smaller area than at Moon Island, and none of it approaches any inhabited shore. An odor of sewage from this outlet is noticeable to persons in boats or vessels sailing in the immediate neighborhood of the outlet.

OTHER OUTLETS IN THE NORTH METROPOLITAN SEWERAGE DISTRICT.

East Boston. — Population in 1900, 45,756. The first sewers in East Boston were built many years ago, and the combined plan has been used in the construction of all the sewers. Nearly all of the sewers are now connected with the metropolitan sewerage system, but there are still about seven independent outlets, chiefly for small areas, which are not connected with the metropolitan system. It appears that one of these sewers was formerly connected with the metropolitan system, but was shut off on account of danger from gas or other inflammable matter, which finds its way into the local sewer.

Two of the outlets discharge into the Chelsea River, one at the foot of Glendon Street and the other at the foot of Putnam Street. Both of the areas from which sewage is discharged at these outlets are small. At Glendon Street the sewage is discharged at the edge of the street, and at low tide flows across flats for a distance of more than 100 feet to the water. The conditions about this outlet are offensive. The Putnam Street outlet is carried to the end of a long wharf, where it is discharged at the edge of the water at low tide. This outlet is at a greater distance from dwelling houses than the Glendon Street outlet, and the odors from it are probably not noticeable at any dwelling house in the neighborhood. The conditions are objectionable about the outlet, however, on account of the deposit of sewage upon the flats in its neighborhood.

The principal outlet discharging into Boston harbor at East Boston is at the easterly end of Moore Street, where a sewer discharges under the northerly end of the Boston, Revere Beach & Lynn Railroad bridge. This outlet discharges upon a wide area of flats exposed at low tide, and the sewage flows several hundred feet before reaching the water. A deposit of sewage along the surface of the flats about the outlet renders them filthy and offensive.

There is a small outlet at the extreme northerly end of Coleridge Street which evidently discharges a very small quantity of sewage, and the wide areas of flats about this outlet do not appear to be very seriously polluted from this cause.

There are three other small outlets at the extreme northerly end of East Boston, in the neighborhood of the Boston, Revere Beach & Lynn Railroad bridge. These outlets discharge into tidal waters flowing from the Chelsea River to the harbor, and objectionable conditions were not found in this neighborhood.

The objectionable sewer outlets in East Boston could be abolished by connecting the sewers with the metropolitan main sewers, which were designed to receive the sewage from all of the sewers in the district. Sewers of considerable length will be required to connect some of these outlets with the metropolitan system.

Chelsea. — Population in 1900, 34,072. The construction of sewers in Chelsea was begun many years ago, and the greater part of the city is provided with sewers built upon the combined plan; but the separate system has been adopted for the sewerage of portions of the city, and this was one of the first places in the State to employ the separate system.

The city is included in the north metropolitan sewerage system, and this system, with its branches, is available for the removal of all of the sewage excepting the excess of flow from the combined sewers at times of heavy rain; but, notwithstanding that the metropolitan sewers have now been available for many years, the sewage of nearly a third of the area of the city, probably containing nearly half of its population, is discharged directly into the adjacent waters at several outlets, at some of which there are very offensive nuisances at the present time.

A sewer in Spruce Street, which receives the sewage of a very large and densely populated section of the city, now discharges into the Island End River at the northerly boundary of the United States hospital grounds, opposite the works of the New England Gas and Coke Company. There are large areas of flats adjacent to this sewer outlet, and the conditions about it are extremely foul. There are no dwelling houses in its immediate neighborhood, but the locality is not far from a dense population, and large numbers of people use the unoccupied land about this outlet as a pleasure resort in summer. As already stated, this sewer was at one time connected with the metropolitan sewerage system, but it appears that the connection was shut off by the Chelsea authorities in the spring of 1898.

Another of the principal sewers of Chelsea discharges into the Chelsea River at the foot of Pearl Street, under the northerly end of the bridge leading to Meridian Street in East Boston. This outlet is located in a densely populated district, and at times of low water the odor about the outlet is very offensive. A considerable deposit of sewage has taken place in the neighborhood of this outlet; but very little of this deposit or of the bottom of the river in this neighborhood is exposed at low water, so that the nuisance created is slight, as compared with the nuisance at the Spruce Street outlet described above. This nuisance could also be removed without difficulty by discharging the sewage into the metropolitan sewerage system, which was designed to receive it, and with which a connection has already been made; but this connection was sealed by the Metropolitan Sewerage Commission in 1898, on account of the neglect of the Chelsea authorities to maintain this sewer in proper condition, and the connection does not appear to have been used since that time.

Opposite the end of Highland Street there is an outlet for a sewer draining a considerable district which discharges into a dock, the greater portion of the bottom of which is exposed long before the water reaches low tide. The dock is used as a place of storage for old vessels and piles. The sewage discharges at the sea wall at the edge of Marginal Street in a thickly populated district, and when the tide is low finds its way through various channels in the mud to tide water. Much matter from the sewage has deposited upon the bottom of the dock, and the conditions about this outlet are extremely offensive at times of low tide. This sewer could evidently be connected with the metropolitan sewer in Marginal Street without serious difficulty or expense, and the discharge of sewage into the dock avoided.

The sewage of a considerable district in the south-easterly part of Chelsea discharges into a small tidal creek near the northerly side of the Boston & Albany Railroad at Chester Avenue, and finds its way through the creek to the Chelsea River, a distance of several hundred feet. The bottom of the creek is uncovered at times of low tide, so that this outlet is an open sewer for a distance of a quarter of a mile or more. This outlet is an offensive one, but there is no considerable population in the immediate neighborhood. It could be discontinued without special trouble by making a connection with the metropolitan sewer in Eastern Avenue, which crosses the creek through which the sewage now flows.

Sewage from two small areas, which are provided with sewerage upon the separate plan, now discharges into Mill Creek at the northerly side of Chelsea. One of these outlets is a small one for a few houses along a single street, and the metropolitan sewer now being constructed to receive the sewage of Revere will soon be available for the removal of sewage from this outlet. The remaining outlet into Mill Creek is located at a long distance from dwellings. It could be abolished without difficulty by a connection with the metropolitan sewer, which this sewer crosses just above its outlet.

BEVERLY.

Population in 1900, 13,884. The construction of a combined system of sewers in Beverly was begun in 1894, but the sewerage system is probably used at the present time by only about 1,000 people. The main outlet discharges into Beverly harbor east of Stone Street about 700 feet from the shore, and at the times it has been examined the presence of the sewage was not noticeable. Much of the sewage of the easterly portion of the city, including that from several factories, employing in the aggregate about 1,000 operatives, in the neighborhood of the railroad station is discharged into a system of storm-water drains which has an outlet into a small tributary of the Bass River on the easterly side of the eastern division of the Boston & Maine Railroad, just south of the junction with the Gloucester branch. The conditions about this outlet were objectionable at the time it was examined, and an odor from the sewage was noticeable in the vicinity. A proper outlet for this sewage should be provided.

FAIRHAVEN.

Population in 1900, 3,567. The town of Fairhaven is located on the easterly shore of New Bedford harbor, and sewers were first constructed in 1891, and have been extended through the greater portion of the main village. It is estimated that about 1,500 persons are connected with the sewers. Sewage from the main portion of the system, which was constructed in 1895, is collected in a system of separate sewers, and pumped by means of compressed air to an outlet at the end of Union Wharf in New Bedford harbor. This outlet is apparently completely submerged at all times, and objectionable odors from it are probably not noticeable excepting to those who use the wharf. There is only one storm-water drain in this area, storm water being allowed to flow through the gutters to the nearest water courses.

In 1900 the south side sewer, so called, was constructed, and discharges at the wharf of the Atlas Tack Company into deep water. The system draining to this outlet is constructed on the combined plan, and drains a territory of about 80 acres, in which there is a population of about 500. A little over one-fifth of the dwelling houses are connected with the sewers. The outlet is not objectionable. At about the time this system was completed a drain was constructed in the new boulevard, which discharges at an outlet under the Fairhaven and New Bedford bridge. This drain was built primarily for surface water, and the outlet is not an objectionable one for this purpose.

FALL RIVER.

Population in 1900, 104,863. The city of Fall River is situated on the easterly shore of Mount Hope Bay, at the mouth of the Taunton River, between the bay and the Watuppa lakes. The Quequechan River, the outlet of these lakes, flows down to the bay through the central portion of the city. The natural drainage of most of the city is toward Mount Hope Bay, but the central portions drain toward the Quequechan River, and part of the densely populated portions is on the slope toward the North and South Watuppa lakes. The main sewer outlets discharge into the Taunton River and Mount Hope Bay.

Sewers were first built in Fall River about fifty years ago, but only about three miles had been constructed previous to 1873, most of which were intended for the removal of storm water. A general system was designed in 1873, and has been constructed and gradually extended since that time. At the present time nearly all of the thickly settled portions of the city are provided with sewers constructed on the combined plan, and it is estimated that the sewers are used by about 75,000 persons.

In the portion of the city draining toward the Quequechan River there are several separate storm-water drains discharging into the river; and some of the sewers in this portion of the city are intended for sewage only, and only a few catch-basins are connected with them, chiefly for flushing purposes.

There are four storm-water overflows through which sewage and storm water are discharged at times of rain, one discharging into the Quequechan River at Quequechan Street, another into the Quequechan River at Plymouth Avenue, a third into the Quequechan River under Rock Street bridge, and a fourth discharging into "The Creek," so called, — a part of the Quequechan River, near its mouth. A small quantity of sewage is also discharged continuously at the latter place.

About one-third of the fifty mills in Fall River are connected with the city sewers, while the remainder discharge their sewage through private drains into South Watuppa Lake, the Quequechan River and the harbor. There is also a large quantity of sewage discharged through other private drains into the waters about the city.

The sewage from the city sewers is discharged into the Taunton River and Mount Hope Bay, at the mouth of the Taunton River, through ten outlets between the northerly and southerly ends of the city, the distance between the extreme outlets being about three and one-half miles.

With three exceptions there are objectionable conditions at all of the Fall River sewer outlets at the present time, and several of them in the southerly portion of the city discharge at a considerable distance back from high water, and the sewage flows in an open stream a distance, in some cases, of several hundred feet to Mount Hope Bay. Provision appears to have been made for the extension of two of the most objectionable of these outlets — the Globe, or Riverview, Street outlet and the Birch Street outlet — to the bay.*

There is a good current with each tide through the Taunton River and Mount Hope Bay opposite the city, and the width of the river at the narrowest point opposite the city is about a quarter of a mile, while the width of the bay at the southerly end of the city is about one mile. The sewer outlets, however, are so close to shore that the sewage from all of them moves along the shore in the direction of the tidal flow, allowing matters from the sewage to deposit as the tide recedes. These objectionable conditions could probably be obviated by extending the sewers to points of discharge beneath the water at a sufficient distance from the shore so that the sewage would become thoroughly diluted before reaching the shore. The excess of flow of mingled sewage and storm water during rains might be allowed to discharge at the edge of the water without causing serious objection.

It is also desirable that all private drains now discharging through private outlets should discharge into the city sewers.

Description of Sewer Outlets.

Cove Street Outlet. — Located at the southerly entrance to Brightman's Cove, approximately at low tide, and sewage from the outlet is carried by the tide into the cove, in which there is an area of about four acres of flats exposed at low water. This outlet originally discharged into the cove, but was subsequently extended a distance of 200 feet, so as to discharge at the outlet to the cove. A bar has been formed near the mouth of the sewer by material brought down at times of storms, and this bar is exposed at low water. There are no dwelling houses in the immediate neighborhood, but there are noticeable odors from the flats when they are not covered with water.

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* The extension of the Riverview Street outlet was completed toward the end of this year.

Brightman Street Outlet. — Located at the edge of low-water mark, on a rocky and gravelly shore, and matters from the sewage collect among the rocks along the shore for a considerable distance on both sides of the outlet, making the shore offensive at times of low water. The shore near this outlet is thickly populated. This outlet formerly discharged farther back from low water, but was extended to its present location in 1900.

President Avenue Outlet. — Located beneath a wharf. The conditions about it were not offensive at the time it was examined. It appears that deposits of gravel and sand brought down by the sewer take place here, and have to be removed from time to time by dredging.

City Wharf Outlet. — Located beneath the city wharf. The conditions about it do not appear to be objectionable at the present time.

Ferry Street Outlet. — This outlet, the largest in the city, is located under the wharf at Ferry Street, having been extended in 1898 from a point nearer shore. The incoming tide carries the sewage into the old ferry slip near by, and greatly discolors the water for a long distance. South of the outlet there is a beach along which there are numerous boat houses, and on the outgoing tide the sewage is carried along the shore in front of this beach, creating objectionable conditions.

William Street Outlet. — This outlet discharges under the Newport branch of the New York, New Haven & Hartford Railroad, and the sewage finds its way through an open channel to the river, which it joins near the southerly end of the beach referred to above. On the incoming tide this sewage flows along the edge of the beach. The outlet itself is a very objectionable one, and causes a serious nuisance in the neighborhood.

Middle Street Outlet. — This outlet is also located at the edge of the railroad, and the sewage flows in an open stream to the beach. The sewage is highly colored by dyes, and the odor is very offensive. Just below the outlet is a pool of sewage and sludge.

Riverview Street Outlet. — This outlet is located at the foot of a steep bluff above high-water mark, and the sewage flows across the beach in the neighborhood of several boat houses to Mount Hope Bay. The outlet is a very foul one, like those of William Street and Middle Street. In the latter part of the year this outlet was extended, so that the sewage now discharges into the bay through an iron pipe below low water.

Birch Street Outlet. — This outlet is located in Happy Hollow, so called, 700 to 800 feet from the sea, into which the sewage finds its way through an open channel. The outlet is an extremely offensive one, but it is located close to a rendering works, which is also offensive. A separate sewer conveys the wastes from the rendering works to the sea beyond low tide.

Mount Hope Avenue Outlet. — This outlet is under construction, but is not yet complete.

GLOUCESTER.

Population in 1900, 26,121. There is no general system of sewerage in the city of Gloucester, but a system of drainage, built primarily for the removal of storm water, is used for the removal of sewage from a large number of buildings in the central portion of the city. It is estimated that there are about 1,000 buildings from which sewage is now discharged into these various drains.

The principal outlet is a 40-inch brick drain, which discharges through the sea wall at Pavilion Beach, about 900 feet east of the mouth of the canal leading to Squam River, and between high and low water mark. The drainage flows across the beach, and has a disagreeable odor. A 24-inch pipe drain and several smaller drains empty through the sea wall between high and low water into Vincent's Cove. The bottom of this cove is a mud flat exposed at low water, and the sewage finds its way across these flats to the water. The flats were very offensive when visited. These outlets are objectionable, and a proper system of sewerage and sewage disposal is badly needed for the densely populated portions of Gloucester.

HINGHAM.

Population in 1900, 5,059. There is no general system of sewerage in the main portion of the town of Hingham, but there is a system for the disposal of the sewage of a summer settlement at Crow Point.

The system at Crow Point is constructed on the separate plan, and discharges into a small channel several hundred feet from shore. Extensive areas of flats are exposed at low tide in the vicinity of the outlet, but it is not objectionable at the present time.

HULL.

Population in 1900, 1,703. This population represents the population living in the town throughout the year. During two months in summer the population is very greatly increased, and a large number of cottages and hotels are occupied during July and August which are unoccupied during the remaining months of the year. On Sundays and holidays in the summer season there are often many thousands of people at Nantasket Beach and other places along the shore, in the town.

The sewage is discharged into the sea at five separate outlets, the first of which was constructed in 1885. The oldest system receives the sewage from about 150 cottages, from Hotel Pemberton and the Oregon House, the population of which in summer probably amounts to about 1,200. The system also receives storm water. The outlet is located below low water at Hull Gut, and examinations fail to show any evidence of the presence of sewage in the neighborhood.

The next system is a small one, for sewage only, discharging at Stony Beach, and there are at present about 12 houses and the various buildings at Fort Revere connected with the sewer. The outlet is beyond the limit of low water, and no evidence of the sewage was noticeable in the neighborhood at the time the outlet was examined.

The third outlet is located at Point Allerton, where there is a system of sewers constructed on the separate plan, which receives the sewage of about 300 people. The outlet is at low tide, at the outer edge of a rocky beach at a considerable distance from cottages; and, while slight evidences of sewage have been noted here, the conditions have not been found objectionable.

The next principal outlet is near the southerly end of the town, at Atlantic Hill, and receives the sewage of about 60 houses and the Atlantic House, containing in summer probably 800 people. The outlet was formerly carried to deep water, but the pipe has been broken by the action of the waves, and the sewage now discharges among the rocks at the edge of low water, where it discolors the water of a small area about the outlet, but otherwise is not objectionable.

The fifth outlet is located near Green Hill, and discharges the sewage from about a dozen houses into deep water, where the presence of the sewage is not noticeable.

Several hotels and other buildings on Nantasket Beach discharge their sewage through private drains upon the flats on the westerly side of the beach in the neighborhood of the steamboat wharf. There are large areas of flats exposed at low water in this neighborhood, but these outlets have not thus far been noticeably offensive when examined.

LYNN.

Population in 1900, 68,513. The sewers of the city of Lynn have been built from time to time since about the year 1870, and at the present time there are about 50,000 persons connected with them. In 1885 a system of intercepting sewers was begun, to collect the sewage at one main outlet. These intercepters were completed in 1892, and now discharge at a single outlet in Lynn harbor. A very small area is provided with sewers upon the separate plan. There are two storm-water overflows from the intercepting sewers, through which a portion of the flow of the sewers is discharged at times of rain; one being located at Ingalls Avenue, and discharging sewage and storm water into Stacy's Brook, which flows into the sea at the southerly end of the town of Swampscott; and the other at Market Avenue and Box Place, discharging into the harbor. There are said to be a few drains for storm water only, the outlets for which have not been located.

Nearly all of the factories of the city discharge into the sewers, the largest contributors of manufacturing waste being the morocco shops. There are six large establishments of this kind in the city where the entire process of tanning is carried on, and waste water from liming, tanning and dyeing, amounting from 10,000 to 60,000 gallons per day from each factory requires disposal. The wastes from five of these factories are discharged into the sewers, but the waste from one of the factories is discharged into a small stream. Nearly all of the principal shoe shops of the city are connected with the sewers.

The main outfall sewer consists of two rectangular box sewers, each 8 feet high and 4 feet wide. The outlet is located 1,600 feet from shore, at the end of a long, wooden pier, and is about at the edge of ordinary low tide. At time of low neap tides the flats are exposed beyond the outlet. The box sewer is not tight, and at times nearly the entire flow of sewage is discharged at various points along the sewer. A channel 30 to 50 feet in width has been excavated on each side of the box sewer, and this channel at low water is generally filled with sewage which leaks from the sewer, or backs up from the outlet.

Observations of the movement of sewage from this outlet at several times, with the assistance of floats and analyses of the waters about the outlet, show that on the outgoing tide, with light winds, sewage flows southerly and easterly to the main channel of the harbor; but the movement of the sewage is greatly influenced by the wind, and with strong winds, even on the outgoing tide, the sewage is driven toward the shore, and remains in the neighborhood of the outlet. On the incoming tide the sewage is carried toward the shore, and with easterly or southerly winds is carried up to the immediate neighborhood of factories and dwelling houses.

The flats all about this outlet in the upper end of the harbor are very foul from sewage deposits, and give off a very offensive odor at times of low water. It is planned to extend the outlet to a greater distance from shore at some future time. The conditions about this outlet are very objectionable.

NAHANT.

Population in 1900, 1,152. The construction of a system of sewerage in Nahant was begun in 1882, and at the present time the system is available to practically the whole population of the town. The population in the summer is very much larger than shown by the census returns, since this town is largely a summer resort. The system is built on the separate plan, although about nine catch-basins are said to be connected with it in various parts of the town. There are a few private sewers, chiefly from small hotels in the neighborhood of Bass Point.

There are eight sewer outlets discharging into the sea, well below low water, at various points about the peninsula, and no nuisance or offensive odor has been found about any of these outlets in the examinations thus far made. Some of the outlets are located close to bathing beaches, but the sewage did not, apparently, at this time noticeably affect the water at these places.

NEW BEDFORD.

Population in 1900, 62,442. The city is built upon a hill sloping toward the Acushnet River and New Bedford harbor on the east, and to the valley of a small stream which discharges into Clark's Cove on the west. The sewage of about two-thirds of the population of the city discharges into New Bedford harbor through twenty-six sewer outlets, and the sewage from the remaining third of the city is discharged into Clark's Cove through six outlets.

The first sewers in New Bedford were built about 1850. All of the sewers are built upon the combined plan, and in some cases the sewers have replaced water courses which now find their outlets through the sewers. There are one or two sewers for storm water only, built to relieve other sewers which become surcharged at times of heavy rain; and there are three storm overflow outlets, at which sewage mingled with storm water is discharged at times of rain.

The distance from the most northerly to the most southerly of the sewer outlets in the harbor is about three miles.

New Bedford harbor is an arm of the sea, with no considerable river discharging into it, and with a range of tide of about three and one-half feet. Observations have been made in connection with the examination of the sewer outlets, to learn the movements of the currents in the harbor and the probable course of the sewage from some of the more important outlets. The results of these observations show that the currents are weak, and the movement of the sewage is influenced to a great extent by the direction of the wind. With strong westerly winds, greasy matter from the sewage floating on the surface of the water can be readily traced to the Fairhaven shore on the easterly side of the harbor, and particles of paper and other matters from the sewage are carried across the harbor at such times, the course of the sewage being influenced but little by the direction of the tidal flow.

Of the twenty-six outlets discharging into the harbor, about one-third are located in the central part of the city, and discharge at the heads of docks between long wharves. Observations show that there is very little movement of the water in these docks, and the sewage accumulates and deposits occur, and the conditions about all of these outlets are extremely foul.

Above the central portion of the city there are ten outlets, one of which, located at Sawyer Street, has recently been extended beyond low-water mark. This outlet receives sewage from a large population; and, notwithstanding the fact that it is carried beyond low water, there are deposits about the outlet, and an offensive odor is noticeable in the neighborhood.

All of the other outlets in this section of the city are objectionable, and some of them are extremely offensive. There are deposits of sewage about all of these outlets, and sewage matters from them are in some cases spread along the shore for a considerable distance from the outlet.

South of the central portion of the city, where the sewers discharge into docks, there are six or seven outlets, the principal one being at Howland Street, which discharges beyond the edge of low water. There is a considerable deposit of sewage about this outlet, and the odor about it is offensive. There were deposits about all of the other outlets, and in most cases particles of sewage were spread over the beach between high and low water, and the odor about them is in all cases offensive.

Clark's Cove is a very shallow arm of the sea, with very little tidal current at its northerly end, into which the sewage is discharged; and, as the prevailing wind of this region in summer is from the south-west, the sewage remains close to the shore of the cove near the point of discharge during the summer season. The water here is shallow for a considerable distance from the shore, and the sewage mingles with it very slowly. Complaint has been made to the local board of health of the offensive odors resulting from the discharge of sewage into this cove.

The principal sewer outlets discharging into Clark's Cove are located near the line of high water, and the sewage flows across the beach a distance of 200 to 300 feet to the water at low tide. When examined, the beach at the head of Clark's Cove has been found to be covered over a greater part of its area between high and low tide with particles of solid matter from the sewage.

In addition to the sewers of the city there are several private sewers discharging at various places from some of the large mills, and it is estimated that the sewage of 3,200 operatives in mills and factories is discharged through private drains.

The location of all of the New Bedford outlets is objectionable, and practically all of them are very serious nuisances; and it does not appear necessary, under the circumstances, to describe the outlets in detail. Investigations are now being made by the city authorities, with reference to the selection of a suitable outlet or outlets for the sewage of the city.

NEWBURYPORT.

Population in 1900, 14,478. The city of Newburyport is located on the southerly bank of the Merrimack River, near its mouth. The range of tide is about 8 feet, and salt water runs up the river above the city. The effect of the tide is felt many miles farther up stream.

The sewerage system was begun in 1889, and at the present time is generally extended throughout the city, serving a population of about 10,000. The sewers are built for sewage only, and there is a separate system of drains for storm water. Storm water is disposed of through numerous outlets, perhaps thirty in all, which discharge into the river at various points. No sewage is admitted to these drains, and the outlets examined were not objectionable.

The sewage is brought to a single outlet at Lower Long Wharf, so called, at the lower end of the city, the outlet being located at low water, about 200 feet from the shore at high water, and in a channel inside of Half-tide Rocks, about half a mile below the bridge from Newburyport to Salisbury. About this outlet and for a long distance below there are extensive flats exposed at low water; but very little evidence of the sewage from this outlet is noticeable in this neighborhood, and the outlet is not offensive to those living near the shore. A small amount of factory waste is discharged directly into the river, but the effect of this sewage is not noticeable.

PLYMOUTH.

Population in 1900, 9,592. The town is situated on the shore of Plymouth Bay, and the sewage is discharged into Plymouth harbor through several outlets. The construction of a sewerage system was begun in 1893. The sewers of the main system for the central portion of the town are constructed with a view to excluding storm water; but there are at present five catch-basins through which rain water is discharged into the sewers, and many houses have their roofs connected with the sewers.

The main outlet is located about 1,200 feet from shore, at a point in the harbor where the water is 9 feet in depth at low tide. Sewage is discharged continually from this outlet, and there does not appear to be any complaint with regard to it at the present time. The sewage is ordinarily visible over a small area of the water immediately about the outlet. No odor or other effect of the sewage is noticeable anywhere along the shore, and the outlet is probably not objectionable excepting to those using boats anchored in its immediate neighborhood.

There are two other outlets for sewers from the main portion of the town, located at the shore in the neighborhood of the railroad station. These outlets are not carried out to the water at low tide. The southerly one, however, discharges near low water, and was not very offensive when visited, though some odor from it was noticeable in the neighborhood. The more northerly of these two outlets discharges near high water, and the sewage flows in streams across the beach to low water. The conditions about this outlet are very objectionable.

In the northerly part of the town there is a private system of sewerage, receiving sewage from a large number of houses and from a cordage works, and discharging upon the flats a considerable distance above low water, though the outlet is covered at high water. The flats about this outlet are very foul, but the offence is not noticeable on the shore in the neighborhood at the present time. A beach in the neighborhood is used for bathing.

REVERE.

Population in 1900, 10,395. The population of this town is temporarily increased each summer by the presence of great numbers of people at Revere Beach and elsewhere along the sea shore within the town limits.

Sewers were first built in Revere about fifteen years ago, and at the present time the sewage of the central portions of the town is collected mainly into two separate systems of sewers.

The principal system for the central portion of the town discharges into Sales Creek, not far from the Revere station on the eastern division of the Boston & Maine Railroad. There is a considerable area of flats about this outlet which is exposed at low water, and the odor is offensive. There are no houses within several hundred feet of the outlet, so that the odors are not at present noticeable at dwelling houses in this region.

The sewage from a part of Revere Beach and from the Beachmont district in the south-easterly part of the town is discharged at an outlet into the sea about 2,500 feet from shore, near the southerly end of Revere Beach. The sewage is received into a tank, from which it discharges on the outgoing tide and in the earlier portion of the incoming tide. The presence of the sewage is noticeable in the immediate neighborhood of the outlet, chiefly by the discoloration of the water; but no odor or other evidence of sewage has thus far been observed upon the shores at Revere Beach or elsewhere in the neighborhood when this outlet has been examined.

There is also a minor outlet into Mill Creek near Broadway, at which a small quantity of sewage is discharged.

Plans are now being made for the disposal of the sewage of Revere into the metropolitan sewerage system, and a metropolitan branch sewer is being constructed to receive this sewage. These works are likely to be completed within two years, and the further discharge of sewage at local outlets in Revere will probably be discontinued.

SALEM.

Population in 1900, 35,956. The principal portion of the city is situated on a narrow peninsula, between the North River and Salem harbor, and the remaining portion on the north-westerly side of the North River, in the district known as North Salem.

The construction of sewers in Salem was begun many years ago. The present system was begun in 1868, and 9 miles of sewers were in use in 1877. In 1895 there were about 40 miles of sewers in the city, and at the present time sewers have been extended to practically all of the thickly settled portions of the city. The sewers are constructed upon the combined plan, and receive both sewage and storm water.

Nearly all of the sewage is discharged into the North River or into Salem harbor, but there are a few outlets discharging into the South River, an arm of Salem harbor, having a small water-shed.

The North River is grossly polluted by manufacturing wastes, consisting chiefly of wastes from tanneries in the city of Salem and town of Peabody, and by domestic sewage from the city of Salem; and the odor from the stream and from the mud flats in the lower part of its course which are exposed at low water is extremely offensive for a long distance from the stream.

Eight sewer outlets have been located, discharging into North River at the North Street bridge and above as far as the boundary line of the town of Peabody, and two large sewer outlets into the estuary of North River below the North Street bridge, one opposite Howard Street and another opposite Dearborn Street.

The outlets into the walled portion of North River are not noticeable on account of the great pollution of the river from other sources. The outlet opposite the extension of Howard Street discharges into a large pool in the North River flats which are exposed at low tide, and the outlet at Dearborn Street also discharges upon the flats on the opposite or north-westerly side of the stream. These are very objectionable outlets, but the nuisance caused by the deposits of filth from the North River on these flats is so great that the increased nuisance due to these two outlets is probably not noticeable.

There are five principal outlets into Salem harbor, four of which are located in the neighborhood of Palmer's Cove, at the southerly end of the city. These four outlets discharge through wooden flumes, running out to the neighborhood of low tide; but, since these flumes are leaky, much sewage is discharged between high and low tide, and flows over the flats exposed at low water. These outlets are all of them objectionable, and the odors from the flats in this neighborhood are very offensive. There is a large population living on the shore in the neighborhood of these outlets.

The outlet which discharges the largest quantity of sewage is located in a cove on the northerly side of the Philadelphia & Reading coal wharf. This outlet is an objectionable one, and there is a great deposit of sewage in its neighborhood, but there are no dwelling houses within 500 feet or more of the outlet. In addition to these outlets there are several smaller outlets into Salem harbor.

There are eight sewer outlets discharging into the South River. This stream flows in a walled channel in the upper portion of its course, and from a point near the railroad station it flows in a covered channel across the southerly portion of the city to Salem harbor. Most of the outlets discharge into the walled or covered portion, while the remaining ones discharge into the deeper water near the mouth of the river. These outlets greatly pollute the river near its outlet.

SUMMARY.

The objectionable conditions caused by sewer outlets may be divided into two classes: (1) cases in which the quantity of sewage is so great in proportion to the quantity of water with which it is mingled that the water is rendered offensive; and (2) those in which the objectionable conditions are caused by faulty construction or location of the outlet itself.

The objectionable conditions caused by the discharge of an excessive quantity of sewage into a body of water are few among those outlets which discharge into the sea.

At Moon Island, where the quantity of sewage discharged is rapidly approaching the capacity of the works for conveying it to the outlet and the capacity of the tidal currents into which it is discharged, the sea water for a distance of a mile or more from the outlet is rendered offensive by the sewage for about two hours after each discharge, but the sewage quickly disappears after the discharge ceases. Upon the completion of the high-level sewer, now under construction, much of the sewage discharged at this outlet will be conveyed to the new outlet at Peddock's Island.

At Salem the water of the North River, into which a great quantity of sewage and manufacturing wastes is discharged, is rendered extremely offensive; but the effect of the pollution disappears rapidly in the tidal estuary into which the stream flows, so that the water in the lower part of the estuary is not noticeably objectionable, but the flats in this estuary are very offensive when exposed.

Similarly, at New Bedford the water of the Acushnet River near its entrance to the harbor is greatly polluted by the sewer outlets; but, except near the New Bedford shore, the harbor water is not noticeably objectionable. In Clark's Cove also the effect on the water of the cove is confined to the extreme upper end.

Of outlets which are objectionable on account of construction or location of the outlet there is a very large number.

The results of the examinations of sewer outlets into the sea or harbors or other arms of the sea show in general that, when the outlets are located in deep water, where they are submerged at all times, noticeable deposits of sewage rarely take place; and an odor from the sewage is rarely noticeable at any considerable distance from the outlet, even in cases where the movement of the water is slow, provided the water is changed regularly by the movement of the tides. Where outlets discharge into considerable tidal currents well away from shores or from flats exposed at low water, the sewage is quickly removed and dispersed, and evidences of it do not accumulate about the outlet.

Among the outlets where objectionable conditions have not been found may be mentioned the outlet of the north metropolitan sewerage system at Deer Island, which has now been in use for eight years, where from

2,000,000 to 3,000,000 gallons of sewage are discharged each hour at the present time at all stages of the tide. The outlet is off the end of a sand-spit exposed at low water and distant about 1,800 feet from the nearest shore at high water. No deposits have yet taken place upon any of the shores near this outlet, and there is no evidence that deposits are accumulating anywhere. The sewage can be seen upon the surface of the sea water in calm weather for a distance of less than a mile from the outlet, and the oily matters from the sewage which float in a very thin film on the surface of the water may be detected at a somewhat greater distance, but an odor from the sewage is noticeable only to those sailing in the stream of sewage in the immediate neighborhood of the outlet. At times when there is considerable wind, sewage is noticeable at much smaller distances from the outlet than in calm weather; and in times of strong wind it is observable only in the immediate neighborhood of the outlet itself.

There are cases where sewage is discharged below the level of low water, but in such a way that the sewage collects about the outlet, and causes offensive conditions. This is the case especially where sewage is discharged into docks between long wharves or into small bays or arms of the sea, where the sea water is not frequently changed by the movement of the tides, and the sewage consequently receives too little dilution.

At the outlets of sewers which discharge at the edge of low water on a beach or flats, under conditions where there is little or no current, the sewage collects in the water, rendering it offensive to sight and smell, and deposits of offensive matters accumulate. At such outlets matters from the sewage are gradually spread over the beach or flats by the tide, where they remain and cause offensive odors when the shores are exposed.

All of the outlets discharging upon beaches or flats between low water and high water have been found to be objectionable, because there is an offensive odor both from the sewage itself and from the decomposition of sewage deposits which take place about such outlets.

In several cases sewage is discharged into open trenches, even above the level of high water, and all of such outlets examined have been found to be very offensive.

The most objectionable nuisances now existing, as shown by the results of these examinations, are the following: —

SALEM.

The offensive condition of the North River and of the flats and shores about other sewer outlets in Salem has been notorious for many years.

The North River is a tidal estuary, the upper part of which is confined between narrow walls, while the lower part spreads over a wide area, much of the bottom of which is exposed at low water. Great quantities of water, polluted by manufacturing wastes, chiefly from tanneries in the town of Peabody and city of Salem, together with sewage, are discharged into the walled channel. Foul matters from this channel settle on the flats in the estuary below, and to these pollutions is added a large quantity of sewage from sewers of the city of Salem, which discharge directly upon the flats, the whole producing a very great nuisance. On the harbor side of the city many sewers discharge upon extensive flats between high and low water, creating here also very serious nuisances.

Plans for the removal of the sewage of Salem to some suitable outlet are now under consideration by the city.

New Bedford.

Practically all of the sewer outlets in the city of New Bedford cause serious nuisances, and offensive odors and other objectionable conditions exist practically all along the shore of the Acushnet River and New Bedford harbor in front of the city and in the upper end of Clark's Cove. The nuisances are caused by the discharge of sewage above low water, where it spreads out over flats or beaches exposed at low tide, or by the discharge of sewage into docks or coves, where the water changes very slowly.

The nuisance created by the present method of sewage disposal at New Bedford is probably greater than in any of the cities or towns along the sea shore, excepting, possibly, Salem. Plans for a general system of sewage disposal are now being prepared.

Fall River.

At Fall River several of the sewer outlets are located above high water, and some of them discharge many feet back from the sea; so that open streams of sewage, aggregating several hundred feet in length, are now in existence in the city. At several of the outlets which discharge at the edge of tide water objectionable conditions exist, by reason of deposits of sewage about these outlets or along the shore in the neighborhood.

Plans have been prepared for conveying the sewage from some of the most objectionable outlets to points of discharge at the shore of the river or bay; but, unless these outlets are carried well out from shore, objectionable conditions will continue to exist about many of the Fall River outlets. It is probable that in most cases if the outlet should be extended beneath the water beyond the low-tide margin the objectionable conditions caused by odors from sewage and sewage deposits about the outlets would be removed.

Chelsea.

Very offensive sewer outlets exist in the city of Chelsea, by reason of the discharge of sewage in places where it spreads over flats exposed at low water, causing offensive odors from the sewage and from deposits which collect in the neighborhood of the outlets. There does not seem to be any good reason why such outlets should be allowed to exist in this city. The north metropolitan sewerage system was designed to remove the sewage of the city, except such as might overflow from combined sewers at times of heavy rain; and some of the sewers which are the cause at present of very serious nuisances have already been provided with connections in the metropolitan system.

BOSTON.

The most objectionable nuisances existing at the present time in the Boston main drainage or south metropolitan sewerage districts, by reason of the disposal of sewage, are those caused by the outlets of the Stony Brook channels. The channel which discharges into the Back Bay Fens is evidently used largely as a sewer, and much sewage and manufacturing waste is discharged into this channel between Jamaica Plain and the Fens at all times. The channel was built to remove the waters of Stony Brook and prevent the flooding of low areas in Roxbury, and was not intended for use as a sewer. The nuisance in the Back Bay Fens could be prevented by removing all connections through which sewage and manufacturing wastes are discharged into the Stony Brook channel, and discharging this sewage and waste into local sewers. If this channel is to continue to be used as a sewer, it should be treated as such, and the dry-weather flow discharged into the metropolitan or main drainage sewers.

The old Stony Brook channel, which discharges on the northerly side of Beacon Street at the edge of the Charles River, also evidently receives a large quantity of sewage and much foul drainage; and this channel also should either be rebuilt, as proposed by the street department of the city of Boston, and used for the disposal of storm water only, or else should be treated as a sewer and connected with the Boston main drainage or metropolitan sewers.

EAST BOSTON.

The sewers which continue to discharge sewage into the tidal waters about East Boston are in most cases small ones, and except in one case no connection has yet been made between these sewers and the metropolitan system. Objectionable conditions exist about most of these outlets, however, which could be prevented by connecting the sewers with the north metropolitan system, which was designed to remove the sewage of this district and to prevent the pollution of local waters.

REVERE.

The sewer outlets of the town of Revere are objectionable, though serious nuisances have not occurred at either of them. The town has recently decided to join the north metropolitan sewerage system, and branch sewers from the metropolitan system are now being constructed to receive the sewage of the town. Under the circumstances it is probable that the present outlets will soon be discontinued.

BEVERLY.

The main outlet at Beverly is not objectionable, but the outlet at the westerly side of the city near the railroad creates a serious nuisance.

Gloucester.

The city of Gloucester has no general sewerage system. Much of the land on which the city is built is rocky and nearly impervious to water, and much difficulty is experienced in the disposal of sewage and household wastes.

A limited drainage system has been provided, chiefly by utilizing natural water courses, and it has become the practice to discharge sewage into these drains or water courses. Already several hundred houses dispose of a part or all of their sewage in this way, and a system of sewerage is growing up which is producing objectionable conditions in these drains and at their outlets.

A proper system of sewerage and sewage disposal will inevitably be required at this place before many years; and the longer the present system is allowed to develop, the greater will be the cost and difficulty of providing a proper system. It would be to the advantage of the city to prevent the further discharge of sewage from any of the buildings into the drains or water courses, to remove such connections as have already been made, and provide a proper means for disposing of the sewage.

Plymouth.

The main outlet of the town of Plymouth which discharges into the harbor does not appear to cause offensive odors or other objectionable conditions which are noticeable on the shore. It is noticeable from boats in the harbor when in its immediate neighborhood. Sewage is discharged at three other places along the shore in front of the town, and the flats about two of these outlets are greatly polluted by sewage.

Plans are now being prepared for removing some of the sewage from these objectionable outlets to a new outlet, and the use of the objectionable outlets should be discontinued.

Other Outlets.

The sewer outlet at Newpuryport discharges well away from the city and near the ordinary level of low water, and offensive odors or deposits are not noticeable about this outlet.

The outlets at Nahant and Hull have not been found to be objectionable.

The main outlet of the town of Fairhaven, located at the end of a long wharf, has not been found to be objectionable when examined.

The Moon Island sewer outlet, from which great quantities of sewage are discharged on each outgoing tide, on the southerly side of Boston harbor, produces offensive conditions to those sailing in the area covered by the sewage soon after it is discharged; but deposits do not appear to be taking place about this outlet, nor have other objectionable conditions been found to exist there.

PART II. — SEWER OUTLETS INTO RIVERS AND OTHER INLAND WATERS.

All of the larger rivers of the State are polluted in a greater or less degree by the sewage of cities or towns or by manufacturing wastes from factories and mills located along the streams or their tributaries. In some cases the pollution is slight, and not detectable by sight or smell excepting in the immediate neighborhood of the outlet of a sewer or just below a mill; while in extreme cases the water of the stream is rendered filthy and offensive for many miles.

In making examinations of sewer outlets into rivers and other inland waters, in order to determine the effect of sewage disposal, it has been necessary to investigate not only the local conditions about the sewer outlets, but also the general effect of the sewage on the stream.

Upon most of the important streams of the State stations were established several years ago, at which samples of the water of the stream have been collected monthly for analysis, the results of which show in a general way the changes in the condition of the stream from month to month and from year to year at these places.

During the past year the sewer outlets of the various inland cities and towns having sewerage systems have been located, and the conditions about them examined. In connection with this examination the condition of the various streams has been inspected, and numerous samples of water have been collected for analysis at many points along their courses. Measurements have been made of the flow of the streams, in some cases at several points, and wherever practicable the quantity of sewage discharged from the different cities and towns has also been measured. Information has also been collected as to the extent of the sewerage systems of the various cities and towns, and as to the quantity and character of manufacturing wastes discharged into the stream from the principal manufacturing establishments.

The year 1902 has been a favorable one for the disposal of sewage into streams and inland waters, with a minimum of pollution or of annoyances from odors or other objectionable conditions caused by such disposal of sewage. The rainfall during the year has been about the normal, and the distribution was such that the flow of streams was high during the summer and autumn months, the period when the flow of streams, and consequent dilution of sewage, is least. At the same time the summer was an exceptionally cool one, and less favorable to the rapid decomposition of organic matters and the production of offensive odors than warmer summers.

About 58 inland cities and towns now have systems of sewerage which are available to a large portion of the inhabitants.

In some of the cities and towns works have been introduced for the treatment and purification of the sewage, and at most of these works the sewage is well purified, so that it does not have an unfavorable effect on the appearance or odor of the stream into which it flows. Practically all of the purification works in the State have been built since the year 1889, when the first works of considerable importance were completed at Framingham.

In the following table is given a list of the cities and towns having sewerage systems available to a considerable portion of the population, together with the name of the stream into which the sewage or effluent is discharged. There are many places having a few sewers or a system for a small portion of the town only, which will be referred to in another place. In cases where much of the sewage is filtered or treated at works for the purification of the sewage, the fact is noted in the table.

TABLE SHOWING THE INLAND CITIES AND TOWNS IN MASSACHUSETTS HAVING SYSTEMS OF SEWERAGE, AND THE STREAM OR OTHER BODY OF WATER INTO WHICH THE SEWAGE OR EFFLUENT FROM SEWAGE PURIFICATION WORKS IS DISCHARGED.

CITY OR TOWN.	Stream or Body of Water into which Sewage or Sewage Effluent is discharged.	Remarks.
Amesbury,	Powow River,	Tributary of Merrimack River.
Amherst,	Fort River,	Tributary of Connecticut River.
Andover,	Shawsheen River,	Tributary of Merrimack River. Purification works.
Athol,	Miller's River.	
Attleborough,	Ten Mile River.	
Billerica,	Concord River,	Purification works.
Brockton,	Salisbury Plain River,	Tributary of Taunton River. Purification works.
Chicopee,	Chicopee River.	
Clinton,	South Branch Nashua River,	Purification works.
Concord,	Concord River,	Purification works.
Dalton,	Housatonic River.	
Easthampton,	Williston Mills Pond,	Mill pond on Broad Brook. Broad Brook joins the Manhan River, a tributary of the Connecticut, 1 mile below sewer outlet.
Fitchburg,	North Branch Nashua River.	
Framingham,	Bannister Brook,	Tributary of Sudbury and Concord rivers. Purification works.
Franklin,	Brook,	Tributary of Charles River. Purification works.
Gardner,	Otter River,	Tributary of Miller's River. Purification works.
Great Barrington,	Housatonic River.	
Greenfield,	Green River,	Tributary of Deerfield River.
Haverhill,	Merrimack River.	
Holyoke,	Connecticut River.	
Hopedale,	Mill River,	Tributary of Blackstone River. Purification works.
Lawrence,	Merrimack River.	
Lee,	Housatonic River.	

TABLE SHOWING THE INLAND CITIES AND TOWNS IN MASSACHUSETTS HAVING SYSTEMS OF SEWERAGE, AND THE STREAM OR OTHER BODY OF WATER INTO WHICH THE SEWAGE OR EFFLUENT FROM SEWAGE PURIFICATION WORKS IS DISCHARGED — *Concluded.*

CITY OR TOWN.	Stream or Body of Water into which Sewage or Sewage Effluent is discharged.	Remarks.
Leicester,	Brook,	Tributary of Blackstone River. Purification works.
Lenox,	Housatonic River,	Purification works.
Leominster,	Monoosnock Brook,	Tributary of North Branch of Nashua River.
Longmeadow,	Connecticut River,	Purification works.
Lowell,	Merrimack River.	
Ludlow,	Chicopee River.	
Marlborough,	Brook,	Tributary of Sudbury and Concord rivers. Purification works.
Maynard,	Assabet River,	Tributary of Concord River.
Medfield,	Charles River,	Purification works.
Methuen,	Spicket River,	Tributary of Merrimack River. Methuen sewage discharges into sewers of city of Lawrence.
Middleborough,	Nemasket River,	Tributary of Taunton River.
Milford,	Charles River.	
Montague,	Connecticut River.	
Natick,	Bannister Brook,	Tributary of Sudbury and Concord rivers. Purification works.
North Adams,	Hoosick River.	
Northampton,	Mill River,	Tributary of Connecticut River.
North Andover,	Shawsheen River,	Tributary of Merrimack River.
North Brookfield,	Quaboag River,	Tributary of Chicopee River. Purification works.
Orange,	Miller's River.	
Palmer,	Quaboag River,	Tributary of Chicopee River.
Pittsfield,	Housatonic River,	Purification works.
Shelburne,	Deerfield River.	
Southbridge,	Quinebaug River,	Purification works.
South Hadley,	Connecticut River.	
Spencer,	Quaboag River,	Tributary of Chicopee River. Purification works.
Springfield,	Connecticut River,	A portion of sewage is discharged into the Chicopee River.
Stockbridge,	Housatonic River,	Purification works.
Taunton,	Taunton River.	
Ware,	Ware River,	Tributary of Chicopee River.
Webster,	French River.	
Westborough,	Assabet River,	Tributary of Concord River. Purification works.
Westfield,	Westfield River.	
West Springfield,	Connecticut and Westfield rivers.	
Williamstown,	Hoosick River.	
Worcester,	Blackstone River,	Purification works.

In addition to the pollution caused by the sewage of the cities and towns given in the foregoing table and by the discharge of sewage at private outlets, most of the streams of the State are also polluted by solid and liquid wastes from manufacturing processes discharged from factories and mills. While the act under which these investigations are made mentions only the sewer outlets of cities and towns, it has been deemed essential to obtain information also as to the character and quantity of the manufacturing wastes discharged into the various streams, since it is well known that some of the most objectionable nuisances are due solely to such wastes. Information relative to the quantity of objectionable wastes discharged into streams from factories and mills has therefore been collected, and is presented in connection with the results of the examination of sewer outlets.

Before proceeding to consider these results in detail, certain general conditions affecting the disposal of sewage into streams and ponds will first be referred to.

Absolutely pure water is not found in nature, and all natural waters in the State contain mineral and organic matters taken up from the vegetation, the soil and the rocks with which the water comes in contact. The quality of the water of most of the larger rivers and ponds in Massachusetts is also affected directly or indirectly by sewage or other wastes of human life.

In the consideration of the sanitary condition of the inland waters of the State, those waters which are not affected by the wastes of human life may be classed as normal, while those which are polluted by sewage or manufacturing wastes are classed as polluted waters. For the purposes of this report the waters of sparsely populated water-sheds unaffected by direct sewage pollution will be assumed to be normal.

The Natural Character of Unpolluted Waters of Streams and Ponds in Massachusetts.

The chemical analyses of unpolluted waters from many streams and ponds show that natural waters differ greatly in character. These differences are due to differences in topography, and in the character of the soil and the rocks of the water-sheds from which the waters are derived. The waters of streams and ponds derived from water-sheds free from swamps or meadows are usually nearly colorless, and contain but little organic matter; while waters derived from swampy water-sheds are generally highly colored, and contain a comparatively large quantity of organic matter.

The quantity of mineral matter present naturally in the waters of most streams and ponds in Massachusetts is small, but in some portions of the State the mineral matter naturally present in the water is high, owing to the presence of limestone.

The results of chemical analyses of normal waters from many different sources show, upon comparison, marked differences in the quantity and character of the organic matter present in the water, in the color, in the quantity of mineral matters present and in other respects. In the following tables characteristic analyses from several different sources are presented, illustrating some of the more important differences in the character of normal waters, as shown by chemical analysis.

Chemical Analyses of the Water of Rivers.

[Parts per 100,000.]

Color.	Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Source.
				Albuminoid.								
	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Sus-pended.		Nitrates.	Nitrites.			
.18	7.55	2.18	.0025	.0132	.0109	.0023	.08	.0089	.0001	.34	5.4	South Branch Hoosick River, above Adams.
.15	3.00	1.25	.0007	.0090	.0078	.0012	.08	.0032	.0000	.31	1.6	Middle Branch Westfield River, at Huntington.
.60	4.57	1.92	.0052	.0313	.0229	.0084	.43	.0103	.0001	.66	1.2	Shawsheen River, above Andover.
1.41	6.05	2.43	.0004	.0246	.0208	.0038	.56	.0107	.0000	-	1.5	Ipswich River, at Reading pumping station.
.38	3.62	1.49	.0025	.0190	.0161	.0029	.22	.0050	.0001	.50	0.9	South Branch Nashua River, above Clinton.
.50	3.38	1.51	.0010	.0184	.0167	.0017	.14	.0032	.0000	.60	0.4	Ware River, at Cold Brook Station, Barre.

Chemical Analyses of the Water of Ponds.

.04	3.40	0.95	0015	.0071	.0061	.0010	.11	.0027	.0000	.10	0.4	Lake Pleasant, Montague.
.09	2.80	0.89	.0007	.0123	.0112	.0011	.64	.0020	.0000	.25	0.3	Silver Lake, Pembroke.
.73	3.61	2.04	.0017	.0184	.0161	.0023	.46	.0010	.0000	.83	0.4	Long Pond, Lakeville.
.78	3.91	1.67	.0015	.0173	.0158	.0015	.44	.0042	.0000	.76	0.7	Great Pond, Weymouth.
.16	7.59	1.68	.0059	.0402	.0213	.0189	2.44	.0021	.0000	.17	1.6	Wannacomet Pond, Nantucket.
.33	3.28	1.67	.0039	.0453	.0267	.0186	.15	.0028	.0000	.43	0.8	Ludlow reservoir, Springfield.
.14	2.27	1.06	.0011	.0149	.0122	.0027	.14	.0013	.0000	.33	0.2	Fall Brook reservoir, Leominster.

The analyses presented in the foregoing tables are the results in each case of an average of several analyses of the water of the source at different seasons of the year, and represent, as well as practicable, the average character of the water in each case. It will be seen that there are very great differences in the quantity of the various substances contained in the different waters; and before calling attention to the causes of these differences, it will be of advantage to consider briefly the meaning of the various determinations.

In the interpretation of the results of chemical analyses of the waters of ponds and streams in Massachusetts the quantity of albuminoid ammonia may be taken to represent the quantity of nitrogenous organic matter present in the water. This organic matter may be of three different classes: first, that which is dissolved from the vegetation and soil with which the water comes in contact; second, that which is due to the presence of living or dead organisms in the water; third, that which is due to pollution by sewage or other wastes of human life.

Organic matter due to the first of these causes is ordinarily very permanent in character, and many experiments with such waters have shown that this organic matter will generally remain constant in composition for months without developing indications of decay. Organic matter of the second class, that which is due to living or dead organisms, has commonly very little effect upon the quantity of organic matter present in streams. The microscopic organisms do not flourish in running water, and have not been found to be present in the water of streams in the State in considerable quantities, excepting in streams which derive a large portion of their flow from a pond or reservoir. In ponds and reservoirs, on the other hand, microscopic organisms often increase largely the quantity of organic matter present in the water, and the number of organisms present may be so great that an odor caused by this organic matter may be detectable in the neighborhood of the pond. This rarely occurs, however, except in cases where the growth is enormous. Upon the decay of the organisms in such cases they sometimes collect in considerable quantities near the shore of a pond, and cause an objectionable odor in their immediate neighborhood.

The free ammonia present in a pond or stream may be taken as evidence of decomposition in progress in the water. Free ammonia is a characteristic ingredient of sewage, and consequently is generally a valuable index of pollution. In general, very little free ammonia is present in normal waters of streams and ponds. In deep ponds, however, the quantity of free ammonia may be large at times, on account of the accumulation of products of decay of organic matters in such waters. In many ponds and reservoirs, especially those of considerable depth, there is a stagnant layer in the bottom during the warmer portion of the year, in which the products of decomposition from the upper layers accumulate, and when the water turns over in the fall, this decomposing organic matter is distributed through all the water of the pond. It is important to take this into account in considering the results of chemical analyses of ponds and reservoirs.

The presence of nitrites, like that of free ammonia, indicates a change going on in the water. In surface waters nitrites are not usually present in any considerable quantity, except in waters polluted by sewage or manufacturing wastes.

The quantity of nitrogen in the form of nitrates present in the surface waters of the State is not usually great, though it is seldom that nitrates are completely absent. The nitrates signify the complete mineralization of organic matter, and the presence of high nitrates must be considered an evidence of the previous pollution of the water. They are rarely present in significant quantities in surface waters, since they furnish a ready food for organisms of all kinds in water exposed to light.

All of the waters of unpolluted sources in the State contain chlorine, one of the component parts of common salt; and one of the earliest results of the regular examinations of inland waters in Massachusetts was the discovery that the quantity of chlorine present in normal waters diminished regularly as the distance from the sea shore increased. It was thus practicable to establish very closely for all parts of the State a normal chlorine, showing the natural amount of chlorine present in unpolluted waters, which, though somewhat variable, varies within narrow limits. This fact has been of the greatest importance in the investigations of the pollution of streams and ponds, as well as other sources, since chlorine is a characteristic ingredient of sewage and does not change, and the excess of chlorine in any water above the normal for that water-shed is an index to the degree of sewage pollution which the water has received. The normal ranges from approximately 2 parts per 100,000 close to the sea shore to about .05 of a part in the extreme western part of the State. The chlorine present in sewage of cities and towns in the State ranges from 3 to 15 parts per 100,000.

The color observed in surface waters is derived from vegetation, such as wood, leaves and grasses and peaty soil. Water which has been long in contact with vegetable matter in swamps has a deep color, usually a yellowish brown.

The oxygen consumed may be taken to represent the carbonaceous matter in the water. Natural waters derived from swampy water-sheds are high in oxygen consumed, while in waters containing but little organic matter the oxygen consumed is low.

The residue on evaporation shows the amount of mineral and organic matter in water. In normal waters the amount of residue depends on the character of the soil and rocks of the water-shed from which the water is derived. In the greater part of the State the character of the soil and rocks is such that the total solids in normal waters are small, — often less than 2 parts per 100,000. In the western portion of the State and in a small area in the north central portion the natural waters contain much more mineral matter, on account of the presence of limestone in these regions, which is readily dissolved and taken up by the water.

Referring now to the table of analyses on page 316, it will be seen that the color and quantity of organic matter, as represented by the albuminoid ammonia, in the waters of the Shawsheen and Ipswich rivers, for example, is much greater than in the waters of the Hoosick and Westfield rivers. The excessive color and organic matter present in the waters of the Ipswich and Shawsheen rivers are due to the contact of those waters with vegetable matters in swamps. The water-sheds of these rivers are, for the most part, quite flat, and there are extensive swamps along the main streams and their tributaries, through which the water falling upon the surface of the ground passes very slowly to the streams, giving abundant opportunity for the water to take up organic matter from the vegetable matter with which it comes in contact. The Hoosick and Westfield rivers, on the other hand, flow from water-sheds having steep slopes, with few swamps and meadows; and the water from the rainfall flows off rapidly into the streams, without opportunity to stand for any considerable time in contact with leaves or other vegetable matter.

While the quantity of albuminoid ammonia present in the waters of the Ipswich and Shawsheen rivers is very large, as compared with that present in the waters of the Hoosick and Westfield rivers, organic matter of this kind, as already stated, is very permanent in character; and although this organic matter, together with the high color and vegetable odor characteristic of these waters, would make them undesirable for the purposes of a public water supply, such waters are not injurious for drinking, and, when unpolluted, will not become in any way offensive when flowing in a stream or stored in a pond or reservoir. Notwithstanding the large quantity of organic matter contained in such waters, as compared with the waters of the Hoosick and Westfield rivers, there is no evidence that pollution by sewage or manufacturing wastes has a more noticeable or more injurious effect upon them than upon the waters of streams which contain but little organic matter.

The analyses of the waters of the Ware and Nashua rivers given in the table illustrate the character of the water of streams in hilly regions containing somewhat more swampy land than the water-sheds of the Westfield and Hoosick rivers, but much less than those of the Shawsheen and Ipswich rivers.

The analysis of the water of the Hoosick River shows, in the high total residue on evaporation and in the hardness, the effect of the presence of limestone within its water-shed, — a substance which is not present, in any considerable quantity at least, in the water-sheds of the other sources mentioned in the table.

In the table of analyses of waters of ponds and reservoirs it will be seen that there is even a wider difference between the quantity of organic matter present in the waters of the different sources than in the case of the rivers. The waters of Lake Pleasant in Montague and Silver Lake in Pembroke are similar in character to many pond waters derived from water-sheds free from swamps, and which are stored in ponds having bottoms nearly free from organic matter. The water-shed of Lake Pleasant in Montague consists partly of steep hillsides and partly of a flat, sandy plain. The water-shed of Silver Lake consists largely of gently rolling country, having a coarse, gravelly soil, so that much of the water enters the lake by percolation through the ground. The water-sheds of Long Pond in Lakeville and Great Pond in Weymouth contain large areas of swampy land,

and the waters from these water-sheds are characterized by a high color and a much larger quantity of organic matter than the waters from the water-sheds previously mentioned. This organic matter, like that of the Ipswich and Shawsheen rivers, is of the stable kind, and both ponds are sources of public water supply, as are Lake Pleasant and Silver Lake.

The analyses of the next two sources — Wannacomet Pond and Ludlow reservoir — show the character of the water of ponds affected at times by great growths of microscopic organisms. These organisms render these waters, which are used as sources of public water supply, offensive to taste and smell at certain seasons of the year. The odor of the water of these sources, when the organisms are most abundant, can be noticed near the shores of the ponds, and masses of organisms sometimes collect near the shores, and cause an offensive odor in their neighborhood.

Artificial storage reservoirs present the same general characteristics as natural ponds. The water of Fall Brook reservoir, the analysis of which is presented in the table, is low in color and organic matter; while the water of Ludlow reservoir contains usually an excessive number of organisms during the greater portion of the year, and a very large quantity of organic matter.

The greatest differences in the quantity of organic matter present in a water are found in the waters of the sources most affected by microscopic organisms. The quantity of organic matter present in the waters of Wannacomet Pond and the Ludlow reservoir in the summer season may often rise to three or four times the average quantity mentioned in the table. On the other hand, the waters of the ponds lowest in organic matter shown in the table do not vary greatly from month to month; nor do the brown waters drawn from swampy water-sheds, though high in organic matter, show material variations. The seasonal changes in the quantity of organic matter present in the water of the various sources are illustrated by the following tables, which show the quantity of albuminoid ammonia present at different seasons of a year in the waters of several of the sources mentioned in the tables.

QUANTITY OF ALBUMINOID AMMONIA IN RIVER WATERS IN DIFFERENT MONTHS OF THE YEAR.

RIVER.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
South Branch Hoosick, above Adams,	.0082	–	–	–	.0117	.0124	.0162	.0142	.0180	.0136	.0112	–
Middle Branch Westfield, at Huntington.	.0142	.0078	.0108	.0086	.0078	.0104	.0088	.0072	.0098	.0116	.0048	.0064
Ipswich, at Reading pumping station,	.0276	.0238	.0184	.0312	.0312	.0286	.0214	.0158	.0330	.0180	.0218	.0250
South Branch Nashua, above Clinton,	.0164	.0128	.0306	.0192	.0192	.0188	.0202	.0248	.0204	.0126	.0174	.0160
Ware, at Cold Brook station, Barre,	.0154	.0114	.0118	.0110	.0208	.0208	.0222	.0248	.0232	.0220	.0198	.0176

QUANTITY OF ALBUMINOID AMMONIA IN POND WATERS IN DIFFERENT MONTHS OF THE YEAR.

POND OR RESERVOIR.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
Lake Pleasant,	–	.0068	–	–	.0058	–	–	.0074	–	–	.0086	–
Silver Lake,	–	.0122	–	.0098	–	.0136	–	.0106	–	.0116	–	.0160
Long Pond,	–	.0198	–	–	.0174	–	–	.0176	–	–	.0188	–
Great Pond,	.0190	–	–	.0176	–	–	.0160	–	–	.0168	–	–
Wannacomet Pond,	–	–	.0114	–	–	.0166	–	.1041	.0635	.0284	–	.0170
Ludlow reservoir,	.0358	.0314	.0300	.0186	.0210	.0398	.0400	.1052	.0584	.0660	.0586	.0390
Fall Brook reservoir,	.0138	.0138	.0130	.0144	.0190	.0172	.0156	.0154	.0150	.0132	.0132	.0148

The differences in the natural quality of the water of a stream from month to month and from year to year are ordinarily of little consequence in considering the effect of the pollution of streams; but, as shown by the results given in the tables, there are instances, especially in the case of ponds, where it is important to take such differences into account.

The foregoing analyses of the waters of rivers and ponds indicate that there are wide differences in the quantity of organic matter present in natural waters at different seasons of the year and under various conditions; and experience has clearly shown that the determination of the albuminoid ammonia in water does not in itself convey any information as to the character of the organic matter in the water, and that, in order to determine the significance of the organic matter shown by the albuminoid ammonia, in a given water, it is necessary to make certain other determinations, and to have a knowledge of the source of the water and the circumstances by which its character may be affected.

It will be seen from the tables that a considerable quantity of free ammonia is present in the waters of streams and ponds unaffected, or not materially affected, by sewage pollution, but that the quantity of nitrites in such waters is low. The nitrates, as already indicated, are of little importance in the consideration of the quality of surface waters. The oxygen consumed and the color of the water follow in general the quantity of albuminoid ammonia.

Microscopical organisms which, when present in large numbers, affect greatly the quality of the water of ponds and reservoirs, are not found naturally in river waters in any considerable numbers, excepting in rivers whose waters are derived largely from lakes and ponds; and the presence of microscopical organisms in river waters is not generally important in the study of the sanitary condition of a stream. Many organisms of the larger varieties, however, flourish in streams under conditions adapted to their growth; and many sewage-polluted streams contain plants or organisms common to such streams, and not usually found in unpolluted waters. Great quantities of *Beggiatoa*, *Leptomitus* and similar fungi, white or gray in color, are often present about sewer outlets and in grossly polluted streams, where they grow clinging to the sides and bottom of the stream. The filamentous *Algæ* are often found in great numbers in polluted streams, but usually farther away from the point of pollution than the other organisms mentioned.

Bacterial examinations of the waters of some of the polluted streams have been made in connection with the chemical analyses, but such examinations have not been general. Where such examinations have been made they have consisted only in a determination of the total numbers of bacteria present.

Flow of Streams.

The quantity of water flowing in the streams of Massachusetts varies greatly in different seasons of the year. In a long series of years the quantity of water flowing in the months of May and December represents, on the whole, approximately the average for the entire year; but between these months, in the warmer portion of the year, the quantity flowing is often but a small fraction of the average, while the quantity in the winter and spring is much greater than the average.

The wide difference between the natural flow of a stream in the winter and spring and the flow in summer and autumn is illustrated by the accompanying table, showing the average monthly flow of the Sudbury River per square mile of water-shed for many years: —

Calculated Yield of One Square Mile of Land Surface in Million Gallons.

[Deduced from the observed monthly yield of the Sudbury River water-shed, by making allowance for the yield of the portions covered by water.]

Month	1875.	1876.	1877.	1878.	1879.	1880.	1881.	1882.	1883.	1884.	1885.	1886.	1887.	1888.	1889.
January, ...	2.762	20.029	20.043	55.595	21.592	34.395	10.932	36.999	9.736	29.701	37.445	43.815	80.500	31.855	86.595
February, ...	41.999	39.371	27.195	68.718	48.026	51.849	42.720	67.490	28.326	82.015	37.570	135.830	76.680	56.942	34.282
March, ...	50.005	138.214	149.860	109.820	72.600	43.032	125.790	90.190	51.448	119.380	50.598	64.763	90.075	101.240	42.541
April, ...	93.150	100.260	73.042	48.779	95.262	36.058	48.350	27.454	42.362	87.510	55.738	60.515	80.623	82.360	43.431
May, ...	37.822	36.530	44.080	45.125	37.170	18.198	31.370	40.964	30.118	33.468	42.802	23.576	34.593	51.486	29.212
June, ...	26.363	7.918	19.350	15.925	13.342	7.676	41.490	18.505	11.010	14.033	15.317	7.938	14.312	15.190	20.981
July, ...	10.960	5.236	6.996	5.083	6.034	5.397	10.805	5.035	5.443	8.422	4.794	4.738	5.024	6.307	17.947
August, ...	12.493	14.304	4.067	14.152	11.992	4.477	6.943	3.693	4.835	8.670	7.778	3.763	7.434	11.925	46.000
September, . . .	6.598	5.261	3.079	5.836	5.230	3.716	6.886	7.202	4.033	3.160	5.521	4.348	5.414	33.012	24.647
October, ...	19.832	7.674	17.947	15.339	3.264	2.783	5.992	10.093	4.756	2.964	9.561	5.042	6.563	63.083	38.782
November, ...	38.943	31.557	42.155	50.158	6.124	6.713	11.270	7.019	6.471	5.204	34.405	21.830	11.628	82.900	57.652
December, ...	18.635	13.623	40.962	98.760	13.403	4.947	23.512	9.639	5.333	27.601	36.860	30.757	19.215	95.265	70.904
Totals, ...	359.562	419.977	448.776	533.290	334.039	219.241	366.060	324.283	203.871	422.128	338.389	406.915	435.061	631.565	512.974

CALCULATED YIELD OF ONE SQUARE MILE OF LAND SURFACE IN MILLION GALLONS — *Concluded.*

[Deduced from the observed monthly yield of the Sudbury River water-shed, by making allowance for the yield of the portions covered by water.]

MONTH.	1890.	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.	1899.	1900.	1901.	1875-1901.	
													Total.	Mean.
January,	39.288	93.155	57.025	12.765	20.445	31.258	33.941	25.260	48.013	71.946	22.629	13.446	991.165	36.710
February,	42.822	98.470	27.042	40.478	27.033	15.488	76.476	29.776	85.892	36.741	104.438	8.406	1,435.075	53.151
March,	113.220	139.940	61.295	102.910	71.895	76.718	121.150	81.536	84.835	132.957	115.489	85.446	2,486.947	92.109
April,	58.408	73.870	28.328	65.550	50.642	76.850	47.540	47.767	56.579	82.074	43 737	128.159	1,734.398	64.237
May,	43.383	20.187	39.703	91.045	27.077	22.141	12.860	29.864	42.627	20.560	43.665	94.731	1,024.357	37.939
June,	19.778	13.919	14.983	15.472	15.685	7.310	13.984	31.297	20.661	5.726	13.200	29.509	450.874	16.699
July,	5.574	6.340	7.916	7.088	6.800	8.055	5.347	21.829	9.858	3.903	3.615	10.510	205.056	7.595
August,	5.201	5.680	9.604	5.843	8.714	8.274	3.793	20.862	33.532	3.483	2.624	15.259	285.395	10.570
September,	13.076	7.310	7.855	4.659	5.464	3.913	9.876	6.675	13.218	3.175	2.851	10.842	212.857	7.884
October,	68.475	6.334	5.149	6.616	10.754	39.582	18.608	5.046	34.479	4.290	5.587	14.089	432.684	16.025
November,	38.340	8.974	19.610	9.853	25.222	83.563	19.984	25.444	58.353	9.723	17.930	14.431	745.456	27.609
December,	29.642	16.206	15.753	23.752	21.026	56.145	20.691	48.414	57.231	6.926	34.728	79.456	919.336	34.051
Totals,	477.207	490.385	294.263	386.031	290.757	429.297	384.250	373.770	545.278	381.504	410.493	504.284	10,923.650	404.579

There are water-sheds which contain very extensive areas of coarse sandy or gravelly soil, which absorb much water from the rainfall in the winter and spring months, and yield it gradually to the streams in the drier portion of the year, thus maintaining a much higher flow in the drier season than is indicated by the flow of the Sudbury River. On the other hand, there are streams which become entirely dry in the summer season.

The flow of the Sudbury River, as presented in the table, shows the average flow distributed throughout the twenty-four hours of the day, unaffected by the draft of water from storage reservoirs to increase the flow of the stream, or by other circumstances which affect the quantity of water flowing in most of the streams of the State. The natural flow of nearly all streams in Massachusetts has been modified to a greater or less degree in the development and use of the streams as sources of power in manufacturing. On most of the larger streams of the State there are large storage reservoirs, in which water is collected during the wetter portion of the year, to be used in maintaining the flow of the stream in the drier portion; and accordingly the dry-weather flow of most of the streams of the State is greater than that recorded on the Sudbury River, as given in the table. Observations of the flow of other streams, however, show that the flow of some streams, especially the smaller ones, may be less per square mile in dry weather than that shown by the Sudbury records; and, as already noted, some streams become entirely dry in dry weather.

Factories and mills are operated, as a rule, during a period of ten hours of the day, and the mill ponds above factory dams are drawn upon for the requirements of the factory usually only during these hours. In the drier portion of the year the whole flow of a stream may be drawn through canals, and the bed of the stream may remain uncovered during the daytime, at least, between the dam and the point or points where the water is again restored to the stream. Where a mill pond is of large size, compared to the flow of the stream, it is often practicable to store much of the night flow of the stream, thus allowing the bottom below the dam to remain uncovered for a period of many hours at night or other times when the mill is not running. The variations in the flow of streams, due to their use in manufacturing, are of great importance in connection with the use of the streams as places of sewage disposal.

QUANTITY OF SEWAGE DISCHARGED FROM CITIES AND TOWNS.

The sewage of cities and towns consists of liquid matters discharged from water-closets, sinks, bath-tubs and other fixtures in dwelling houses, stores, offices and factories, together with a greater or less quantity of waste liquors from manufacturing processes in factories and mills; and ordinarily a very large and variable quantity of water which finds its way into the sewers partly by percolation of water through cracks or defective joints in the sewers or in the house sewers connected therewith, and partly, also, at times of rain, by leakage of rain water through perforated man-hole covers or through other direct openings into the sewers. In combined systems of sewerage the sewers also receive great quantities of surface water at times of rain, or when snow is melting; and the flow in such sewers may be increased at such times to a quantity amounting to several times the ordinary flow of sewage, and a considerable quantity of organic and mineral matter may be brought into the sewers in the rain water from street surfaces, etc.

The quantity of water used from the public water supply in a city or town is not a reliable indication as to the probable quantity of sewage flowing in the sewers. The leakage into the sewers from the various causes mentioned increases the quantity of sewage flowing in the sewers of a city or town at times to an amount much beyond the quantity of water used from the public water works.

In the following table records are given of the measurements of flow of sewage from several of the separate systems of sewers of the State, and the quantity of water used from the public water supply: —

AVERAGE FLOW OF SEWAGE AND AVERAGE CONSUMPTION OF WATER, BY MONTHS, 1902.

[Gallons per Day.]

MONTH.	BROCKTON (ESTIMATED POPULATION, 42,820).		NATICK (ESTIMATED POPULATION, 9,758).		FRAMINGHAM (ESTIMATED POPULATION, 12,018)	
	Water.	Sewage.	Water.	Sewage.	Water.	Sewage.
January,	1,338,000	988,000	386,800	906,365	447,438	733,931
February,	1,402,000	793,759	380,000	627,993	402,070	590,226
March,	1,209,000	1,275,499	356,700	1,482,375	378,484	951,970
April,	1,167,000	921,288	379,200	971,287	398,096	801,293
May,	1,464,000	682,506	380,800	503,795	388,580	600,600
June,	1,639,000	597,304	500,000	360,835	441,074	497,745
July,	1,440,000	572,486	392,900	335,634	413,727	446,120
August,	1,448,000	607,565	356,600	209,000	441,307	447,800
September,	1,396,000	607,507	421,400	258,000	493,229	432,150
October,	1,411,000	659,010	412,300	427,700	403,001	463,935
November,	1,258,000	619,917	415,000	262,000	402,975	447,673
December,	1,487,000	904,065	464,400	627,000	429,816	544,055
Average for the year,	1,390,000	767,030	403,800	581,000	420,000	579,800

NOTE. — The sewers in Brockton are not used by so large a proportion of the population supplied with water as in the other places mentioned.

The variation in the flow of sewage in the different seasons of the year is due very largely to variations in leakage of water into the sewers. The flow of sewage from the various systems of sewers is generally highest in the early spring, when the ground is saturated with water, and least in the latter part of the summer or early autumn when the level of the ground water is lowest.

The quantity of sewage flowing from a system of sewers also presents considerable variations from day to day and from hour to hour. The variations in the flow of sewage from hour to hour are well illustrated by the table on page 330.

In order to illustrate the ratio of the flow of sewage from a city or town to the average flow of a stream, the following table is presented, showing the average flow of sewage from one of the separate systems of sewers in the State, the flow of which is not affected by extraordinary conditions, and the average flow of a stream during the same period: —

MONTH.	Flow of Stream (Gallons per Day per Square Mile).	Flow of Sewage (Gallons per Day).	Ratio of Stream Flow to Sewage.
January,	475,000	495,000	.96
February,	4,150,000	639,000	6.49
March,	2,800,000	758,000	3.70
April,	1,980,000	694,000	2.86
May,	1,521,000	651,000	2.34
June,	374,000	608,000	.62
July,	149,000	361,000	.41
August,	169,000	328,000	.52
September,	79,000	332,000	.24
October,	182,000	417,000	.44
November,	993,000	477,000	2.08
December,	951,000	739,000	1.29
Average for year,	1,131,000	542,000	2.09

CHARACTER OF SEWAGE OF CITIES AND TOWNS.

Sewage has been defined as the domestic and manufacturing filth and refuse flowing from sewers, and is to be distinguished from "drainage," which refers to rainfall, surface and subsoil water only. As has been already shown, sewage derived from the various fixtures in dwellings, stores, factories, etc., from which it is discharged into the sewers, is mingled with a greater or less quantity of clean water from the public water supply, and of probably fairly clean water draining from the ground into the sewers through leaks. When the mixture of sewage and waste water in the sewers first takes place, and sewage is brought in contact with comparatively clean water and with the air, the disintegration of the various matters begins, and the sewage becomes rapidly mingled with the water. The decomposition of the organic matter in the sewage goes on rapidly, and solid matters become broken up and finely divided. In cases where sewage is a long time in reaching the outlet, the odor becomes very much more offensive than that of fresh sewage. The strength of the sewage flowing from different systems of sewers differs greatly, on account of differences in the quantity of water used, in the waste or leakage into the sewers, and on account of the quantity and character of the manufacturing wastes discharged into the sewers. This may be illustrated by the following table, showing the average analyses of sewage from different systems: —

[Parts per 100,000.]

Date of Collection.	Residue on Evaporation.						Ammonia.				Chlorine.	Oxygen Consumed.		
	Total Residue.			Loss on Ignition.				Albuminoid.						
	Total.	Dis-solved.	Sus-pended.	Total.	Dis-solved.	Sus-pended.	Free.	Total.	Dis-solved	Sus-pended.		Unfiltered.	Filtered.	
1902	72.02	53.33	18.69	34.92	22.15	12.77	4.7383	.9058	.4983	.4075	10.90	13.02	8.84	Brockton.
1902	38.48	29.67	8.81	16.55	10.90	5.65	2.7750	.4758	.2920	.1838	5.44	3.63	2.43	Framingham.
1902	31.02	26.02	5.00	12.83	9.25	3.58	1.5975	.2807	.1708	.1099	4.63	3.05	2.12	Natick.

The results of the numerous analyses of sewage and of many observations upon the quantity of sewage flowing from different systems indicate that the quantity of putrescible organic matter in ordinary sewage depends rather upon the population connected with the sewers than upon the actual quantity of sewage flowing from the sewers. That is, the total quantity of organic matter discharged in the sewage from a given population is probably approximately the same, whether the quantity of sewage flowing in the sewers is large or small.

This may be illustrated by the following table, in which is given (1) the quantity of albuminoid ammonia in the sewage of four cities and towns in which very little manufacturing waste is discharged into the sewers, determined from the results of numerous analyses of samples collected at frequent intervals, and (2) the calculated quantity of albuminoid ammonia in parts per 100,000 that these amounts would represent if this quantity of organic matter had been contained in 100 gallons of water for each person connected with the sewers.

City or Town.	Albuminoid Ammonia (Parts per 100,000).	Calculated Quantity of Albuminoid Ammonia, on Basis of 100 Gallons per Person connected with the Sewers (Parts per 100,000).
Andover,	.55	.32
Brockton,	.91	.34
Marlborough,	.28	.30
Spencer,	.25	.35

The sewage of many of the cities and towns, however, is stronger in organic matter, on account of the discharge of manufacturing wastes into the sewers, than the sewage of the places mentioned.

Sewage flowing from a system of sewers varies in strength at different seasons of the year. In the summer and early fall, when the leakage into the sewers is least, the sewage is generally strongest; while in the winter and spring, when the leakage is greatest, the sewage is much more dilute. There are considerable variations also in the strength of sewage from day to day. There is a very great variation in the strength of sewage in the different hours of the day, the strongest being found at the time of maximum flow in the day, while the sewage is weakest at the time of minimum flow at night.

The variations in the strength of sewage at different seasons of the year and at different hours of the day are illustrated by the two following tables, the first showing the results of monthly analyses of the sewage from a separate system of sewers, and the second showing the character of the sewage in different parts of the day.

Table showing Results of Monthly Analyses of Sewage from a Separate System of Sewers.

[Parts per 100,000.]

Months.	Residue on Evaporation.	Ammonia.		Chlorine.
		Free.	Albuminoid.	
January,	31.60	3.1400	0.6000	4.37
February,	53.20	5.0000	0.9800	5.40
March,	40.20	3.5400	0.7400	4.85
April,	29.00	0.5900	0.2700	3.80
May,	24.40	1.5500	0.2300	3.70
June,	21.00	0.9000	0.2000	3.20
July,	36.40	3.4200	0.5600	4.80
August,	63.20	5.4000	1.5200	14.05
September,	74.00	4.8000	1.1400	9.00
October,	74.80	7.0000	0.9400	9.20
November,	76.80	7.4000	1.3000	11.10
December,	45.80	2.0300	0.4900	4.90

TABLE SHOWING VARIATIONS IN THE FLOW AND IN THE CHARACTER OF SEWAGE

[Parts per 100,000.]

	Number.	Date.	Hour.	Rate of Flow. — Gallons per 24 Hours.	Temperature. — Deg. F.	RESIDUE ON EVAPORATION.					
						TOTAL RESIDUE.			LOSS ON IGNITION.		
						Total.	Dissolved.	Suspended.	Total.	Dissolved.	Suspended.
1	23355	1898. May 31	11.25 A.M. and 12.12 P.M.	478,500	52.0	79.00	26.50	52.50	55.40	10.00	45.40
2	23356	May 31	1.11 and 2.18 P.M.	474,400	52.0	36.00	24.80	11.20	20.00	10.20	9.80
3	23357	May 31	3.07 and 4.10 P.M.	474,600	52.5	35.60	20.60	15.00	21.00	8.00	13.00
4	23358	May 31	5.08 and 6.09 P.M.	424,400	52.2	24.80	16.20	8.60	11.80	5.20	6.60
5	23359	May 31	7.10 and 8.08 P.M.	391,400	52.5	23.60	18.90	4.70	10.00	6.00	4.00
6	23360	May 31	9.12 and 10.13 P.M.	361,600	51.3	21.40	15.90	5.50	9.20	4.80	4.40
7	23361	May 31	11.15 P.M. and 12.18 A.M.*	335,700	51.0	15.60	13.50	2.10	5.00	3.50	1.50
8	23362	June 1	1.18 and 2.14 A.M.	309,200	50.5	12.20	11.50	0.70	4.40	3.70	0.70
9	23363	June 1	4.09 A.M.	304,700	50.0	12.00	11.20	0.80	3.80	3.30	0.50
10	23364	June 1	5.12 and 6.18 A.M.	311,500	50.5	11.40	11.20	0.20	2.80	2.80	0.00
11	23365	June 1	7.15 and 8.12 A.M.	391,100	50.5	24.00	14.90	9.10	11.40	3.90	7.50
12	23366	June 1	9.10 and 10.02 A.M.	419,400	51.5	47.40	21.50	25.90	30.40	8.10	22.30
13		Average for 24 hours,.....		389,700	51.4	30.90	18.00	12.90	17.10	6.10	11.00

* June 1.

MANUFACTURING WASTES.

Manufacturing wastes of various kinds are very important factors in the pollution of streams, and the present condition of one of the most grossly polluted streams in the State is due almost wholly to the discharge of manufacturing wastes into the stream and its tributaries. The manufacturing wastes which have the most serious effect in polluting streams and are most commonly met with in this State are the wastes from woolen mills, including the wastes from the scouring of wool and the washing and dyeing of cloth, wastes from tanneries, from paper mills, from shoddy mills, from print works and from rubber mills, silk factories and gas works.

The wastes from the processes of wool-scouring usually contain very large quantities of dirt and organic matter of various kinds, and are very serious sources of pollution of streams at many places. An examination of the quantity of water used in scouring wool at many different mills in the State shows that it ranges from approximately 1 gallon per pound of wool scoured to 100 gallons and even 200 gallons per pound of wool scoured. The process in which the smaller quantity is used is becoming a more common one, and this method gives a waste which contains a very large quantity of organic matter and much grease. Characteristic analyses resulting from each process are given in the table on pages 332 and 333.

FROM A SEPARATE SYSTEM OF SEWERS FOR A PERIOD OF TWENTY-FOUR HOURS.

[Parts per 100,000.]

AMMONIA.				Chlorine.	NITROGEN AS		OXYGEN CONSUMED.		
Free.	ALBUMINOID.				Nitrates.	Nitrites.	Unfiltered.	Filtered.	
	Total.	Dissolved.	Suspended.						
2.3400	.5900	.3800	.2100	4.90	.0010	.0000	4.51	1.74	1
1.5200	.5600	.2700	.2900	3.75	.0010	.0000	4.67	1.81	2
0.2170	.5600	.2800	.2800	3.28	.0010	.0000	3.94	1.81	3
1.4900	.3100	.1900	.1200	2.65	.0000	.0000	1.76	1.02	4
2.0800	.4100	.1900	.2200	3.78	.0010	.0000	1.89	1.28	5
1.5300	.2600	.1600	.1000	2.49	.0010	.0000	1.50	0.99	6
0.8680	.2360	.1000	.1360	2.37	.0000	.0000	1.25	0.77	7
0.2960	.0600	.0440	.0160	1.76	.1440	.0192	0.35	0.35	8
0.0960	.0440	.0200	.0240	1.60	.1600	.0176	0.32	0.31	9
0.1640	.0440	.0200	.0240	1.59	.1800	.0160	0.32	0.31	10
2.5700	.3700	.1700	.2000	2.73	.0020	.0000	2.24	1.20	11
3.7700	.6000	.3600	.2400	3.29	.0000	.0000	4.13	2.10	12
1.4940	.3680	.2010	.1670	2.98	.0320	.0040	2.48	1.23	13

In some cases wastes from woolen mills are discharged into a city or town sewerage system, greatly increasing the strength of the sewage. Wool-scouring wastes are very difficult to purify by methods used in the purification of sewage, though they can be readily purified by intermittent filtration when mixed with a large quantity of ordinary domestic sewage. Processes by which the grease, which is the element causing the most serious difficulty in the purification of this waste, can be removed and a valuable product recovered, are in use in some mills.

In the process of washing cloth large quantities of water are used, and this water is grossly polluted in the earlier portion of the process. Toward the end, as the cloth becomes nearly clean, the quantity of organic matter is small. On the whole, this waste has a serious effect in the pollution of streams.

Waste liquors from the process of dyeing contain, as a rule, comparatively little organic matter, especially in cases where aniline dyes are used; and the principal injury to streams resulting from the discharge of such wastes is the discoloration of the water. In some cases much organic matter is washed from the cloth in the processes of dyeing; and in such cases, and in cases in which the heavier dyes are used, very considerable pollution of a stream may result from the discharge of spent dye liquors.

Tannery wastes contain great quantities of putrescible organic matter, and the quantity of organic matter in the wastes from a large tannery may amount to as much as that present in the sewage from a town of considerable size, and its effect upon a stream is similar to that of sewage. A characteristic analysis of tannery sewage is given in the accompanying table. The disinfectants which are sometimes used for the preservation of skins of animals in the course of transportation to a tannery sometimes make the purification of such wastes difficult.

The wastes from paper mills are derived largely from the washing of rags and paper used for stock, and from the water used in paper machines in which the pulp is made into paper. The waste from the washing of stock usually contains much organic matter, and the quantity is large, since a large quantity of water is used. The greatest quantity of water wasted from paper mills comes from the paper machines, and the wastes from some of the larger machines may amount to from 500,000 to 1,000,000 gallons in twenty-four hours. The wastes from paper machines usually contain comparatively little putrescible organic matter; and experiments indicate that such wastes can be efficiently purified by straining, and probably valuable matter recovered that would otherwise be lost. Wastes from the washers and beaters can also probably be purified efficiently in this way in many cases.

Wastes from shoddy mills consist of dirt and organic matter washed from the rags used as stock, and large quantities of acid are often used in these mills. Wastes from shoddy mills have a very serious effect in the pollution of streams.

The following table contains analyses of many of the important manufacturing wastes from mills of different kinds in the State which have the most serious effect in the pollution of streams: —

CHEMICAL ANALYSES OF WASTES FROM VARIOUS MANUFACTURING PROCESSES.

Waste from Washer in Paper Mill.

[Parts per 100,000.]

Rate of Flow (Gallons per Day).	RESIDUE ON EVAPORATION.						AMMONIA.				Chlorine.	OXYGEN CONSUMED.	
	TOTAL RESIDUE.			LOSS ON IGNITION.				ALBUMINOID.					
	Total.	Dissolved.	Suspended.	Total.	Dissolved.	Suspended.	Free.	Total.	Dissolved.	Suspended.		Unfiltered.	Filtered.
200,000	321.60	152.00	169.60	128.80	52.60	76.20	.0500	.4200	.3900	.0300	-	35.00	26.50

Waste from Paper Machine.

500,000	57.00	37.20	19.80	29.20	16.80	12.40	.0496	.0680	.0264	.0416	-	7.32	4.56

CHEMICAL ANALYSES OF WASTES FROM VARIOUS MANUFACTURING PROCESSES — *Concluded.*

Waste from Scouring of Wool.

[Parts per 100,000.]

Rate of Flow (Gallons per Day).	RESIDUE ON EVAPORATION.						AMMONIA.				Chlorine.	OXYGEN CONSUMED.	
	TOTAL RESIDUE.			LOSS ON IGNITION.				ALBUMINOID.					
	Total.	Dis-solved.	Sus-pended.	Total.	Dis-solved.	Sus-pended.	Free.	Total.	Dis-solved.	Sus-pended.		Unfiltered.	Filtered.
400,000*	147.40	75.60	71.80	34.00	12.40	21.60	.0680	.5800	.2900	.2900	-	5.80	4.80
21,000†	1696.00	-	-	1103.00	-	-	6.1000	12.0700	5.8800	6.1900	25.56	136.20	-

Waste from washing Woolen Cloth.

320,000‡	2621.40	1881.60	739.80	1899.00	1344.60	554.40	1.8200	14.8000	8.4000	6.4000	-	760.00	725.00

Waste from a Tannery.

200,000	-	-	-	-	-	-	1.8158	5.7000	2.5200	3.1800	46.31	71.37	-

Waste from Dyeing.

80,000	268.20	260.00	8.20	113.60	108.00	5.60	1.7000	1.2400	.6100	.6300	-	77.50	75.50
-	160.00	149.40	10.60	23.80	18.00	5.80	1.4300	.2100	.1800	.0300	73.20	20.00	10.00

* Two thousand pounds of wool per day. † Four thousand pounds of wool per day.
‡ A very large mill.

OBJECTIONABLE CONDITIONS RESULTING FROM THE DISCHARGE OF SEWAGE INTO STREAMS.

The most objectionable condition that may result from the discharge of sewage into streams or other inland waters is the pollution of a source of water supply. In Massachusetts the use of the larger rivers as direct sources of public water supply without purification has practically ceased; but polluted river waters are still, in many cases, used for washing and other processes in factories and mills where they are available for drinking, and are sometimes so used. The discharge of sewage into a stream may be objectionable, even though the effect of the sewage upon the appearance of the stream may not be noticeable, in cases where the stream discharges into tidal waters from which shell-fish are taken. A sewage-polluted water may also be objectionable for some manufacturing and mechanical purposes.

In general, the most objectionable conditions resulting from the discharge of sewage into inland waters, as shown by these investigations, aside from the pollution of water supplies, are those in which the stream itself is rendered offensive to sight and smell for a considerable portion of its course. Very objectionable conditions have been found at sewer outlets where the quantity of sewage is so small in proportion to the flow of the stream that, with a properly constructed outlet, no offence would be created. Many sewer outlets have been found in which the sewage is discharged at a considerable distance back from the bank or shore of the stream or pond into which the sewage finds its way, and the sewage spreads out over a considerable area, and collects in pools before reaching the water. Nuisances are caused in other cases by outlets located at the bank of a stream or the shore of a pond in a shallow pool or bay, into which little or no water finds its way, and the sewage collects and putrefies, giving off a very offensive odor. Some outlets which discharge into the water, and are not objectionable under ordinary conditions, become offensive at times when the water in the stream or pond recedes in dry weather, allowing the sewage to spread over the exposed bottom. Such nuisances are not found where the outlet extends a sufficient distance into the water to prevent the sewage from returning to the shore until thoroughly mingled with the water. Satisfactory outlets of the latter sort have been constructed in connection with some of the sewers in Springfield and at a few other places.

Observations upon the discharge of sewage into water at many places show that there is much advantage in discharging it at several outlets, since the sewage then mingles much more rapidly with the water, and is subjected more quickly to those actions which tend to remove its effect.

In making the investigations included in this report, inspection has been relied upon in the first place to locate the points of pollution and determine the conditions about sewer outlets and the general condition of the streams. Chemical analyses of the waters of the streams at various points have been made, to determine their condition and the effect of the pollution. In a few cases also bacterial examinations have been made, which are of assistance when used in connection with the other investigations.

Method of making Examinations and presenting Results.

In presenting the results of the examinations of the various rivers and sewer outlets, a table is first given containing a list of the cities and towns within the river basin, with statistics as to the population, sewerage, etc., of the town, and next a table showing the drainage area of the river at various points, with statistics as to the population, etc., on the water-shed. Subsequently a table giving an average of the results of monthly analyses during the six driest months of the year, from June to November inclusive, is presented for all the places within the water-shed where such observations have been made; and finally the results of special examinations of some of the streams are presented, showing the flow of the stream and the condition of the water, as shown by chemical analyses, at various points at the time the special examination was made.

The streams will be considered in the following order: —

Assabet (see Concord).
Blackstone.
Charles.
Chicopee.
Concord.
Connecticut.
Deerfield.
French.
Green (see Deerfield).
Hoosick.
Housatonic.
Manhan (see Connecticut).
Merrimack.
Mill (see Connecticut).
Miller's.
Nashua.
Neponset.
Quaboag (see Chicopee).
Quinebaug.
Seven Mile (see Chicopee).
Shawsheen (see Merrimack).
Sudbury (see Concord).
Swift (see Chicopee).
Taunton.
Ten Mile.
Ware (see Chicopee).
Westfield.

BLACKSTONE RIVER.

The Blackstone River is formed by the junction of Kettle and Mill brooks in the southerly part of the city of Worcester, and flows in a south-easterly direction into the State of Rhode Island.

There are numerous factories on the stream and its tributaries, using the water for power purposes; and the water-shed contains many large ponds and reservoirs used for storage purposes, so that the flow of the stream is well maintained during dry weather.

The following tables give statistics in regard to the drainage areas and the population on them at various points: —

Locality.	Distance Above State Line (Miles).	Drainage Area (Square Miles).	Population on Drainage Area.	Population per Square Mile.	Estimated Population discharging Sewage or Sewage Effluent into River.
Below Worcester sewage purification works,	24.8	69.6	122,300	1,760	124,000
Dam of Cordis Manufacturing Company, Millbury.	22.3	77.9	126,400	1,625	124,800
Dam of Calumet Woolen Company, Uxbridge.	10.4	145.9	137,500	943	126,000
Dam at Millville, ...	3.5	258.1	151,100	587	129,600
Dam of Blackstone Manufacturing Company.	1.0	260.3	154,400	593	131,100
State line, ...	0.0	363.8	164,800	454	-

Cities and Towns, considerable Portions of which are within the Water-shed of Blackstone River.

LOCALITY.	Population in 1900.	Sewerage System.	Estimated Population discharging Sewage or Sewage Effluent into River.	Manufactories discharging Wastes into River.
Leicester,	3,416	General.*	500	Five woolen mills.
Auburn,	1,621	None.	100	Three woolen mills.
Worcester,	118,421	General.*	123,400	Four woolen mills.
Shrewsbury,	1,626	None.	0	None.
Millbury,	4,460	None.	800	Four woolen mills, one cotton mill, one linen mill, one indigo mill.
Grafton,	4,869	None.	800	One cotton mill, one emery mill, one flax mill, one shoe-string factory, one shoe factory.
Sutton,	3,328	None.	0	One cotton mill.
Northbridge,	7,036	None.	3,000	One machine works, one woolen mill.
Upton,	1,937	None.	0	None.
Mendon,	911	None.	0	None.
Douglas,	2,113	None.	300	One woolen mill.
Uxbridge,	3,599	None.	700	One cotton mill, six woolen mills.
Bellingham,	1,682	None.	0	None.
Blackstone,	5,721	None.	1,500	One felt mill, one cotton mill, one rubber works.
Gloucester, R. I.,	1,462	-	-	- -
Burrillville, R. I.,	6,317	-	-	- -
North Smithfield, R. I.,	2,422	-	-	- -

* Sewage purification works in use.

Kettle Brook has its source in the town of Leicester, and flows through Cherry Valley, a village situated partly in the town of Leicester and partly in the city of Worcester. Thence it flows in a circuitous course through the town of Auburn across the southerly portion of the city of Worcester to Quinsigamond Village, where it unites with Mill Brook. The water of the upper portion of Kettle Brook and of two of its tributaries, Lynde and Tatnuck brooks, is used for the supply of the city of Worcester, which materially reduces the flow of the brook; but practically all of the water diverted is returned through the city sewers to the Blackstone River below the junction of the two brooks.

The first sources of pollution on Kettle Brook are the woolen mills in Cherry Valley. There are eight mills, employing about 700 persons, and the sewage from 600 operatives is discharged directly into the stream. At all of these mills large quantities of manufacturing wastes are produced, all of which are discharged directly into the stream. These wastes consist chiefly of spent dyes and water used for washing cloth, which discolor the stream and make it offensive both to sight and smell.

At Jamesville in the city of Worcester, just below Cherry Valley, there is a large woolen mill, wastes from which are discharged into the stream; and at Stoneville and Pondville, two villages in the town of Auburn, there are woolen mills employing about 235 persons, all of the manufacturing wastes and the sewage from about 100 operatives being discharged directly into the stream.

Between Cherry Valley and the point where it re-enters the city of Worcester the brook flows through several large mill ponds, and the appearance of the water is very much improved.

In the south-westerly portion of Worcester the stream receives the wastes from two woolen mills and from a large bleachery and dye works, and the sewage from about 185 persons employed in these factories. Below this point the water is again badly discolored, and otherwise objectionable.

About a mile above its junction with Mill Brook, Kettle Brook receives the sewage and wastes from a carpet factory, where great quantities of wool are scoured, and large quantities of wastes from this process, and from dyeing and washing, are discharged into the stream. Arrangements are now being made for connecting this factory with the city sewers, by which all of the sewage proper and the worst portion of the manufacturing wastes will be removed. Below the carpet factory the city is building a walled channel to contain the brook, which for the remainder of its course is exceedingly foul.

Mill Brook, which unites with Kettle Brook at Quinsigamond Village, flows through the central portion of the city of Worcester, and throughout much of its course is contained within a covered channel, which until recently received practically all of the sewage of the city of Worcester; and the dry-weather flow of the brook, including the sewage, was conveyed to the precipitation works of the city of Worcester, where it was treated with chemicals before being discharged into the Blackstone River.

The city of Worcester contained in 1900 a population of 118,421, and the estimated population in 1902 is 126,000. Practically all of the city is served by sewers which are built on the combined plan. The sewers also receive large quantities of manufacturing wastes from the many mills in the city. By an act of the Legislature, in 1886, the city was directed to purify its sewage before discharging it into the Blackstone River; and purification works were constructed about a mile below the point where the Mill Brook channel discharges into the river, for the purification of the sewage by chemical precipitation. The precipitation works are capable of treating the dry-weather flow of Mill Brook, including the sewage of the city; but at times of storms or melting snow a considerable portion of the flow of the brook has been discharged into the river without treatment.

The quantity of organic matter removed from the sewage by chemical precipitation and sedimentation as practised at Worcester amounts to about 50 per cent. of that present in the sewage, so that even when all of the sewage is being treated, an enormous quantity of organic matter is still discharged into the Blackstone River. In order to provide for the further treatment of the sewage, and to facilitate this by reducing the quantity of sewage to be treated, the separate system of sewerage is being introduced and intercepting sewers are being constructed to divert the dry-weather flow of sewage from Mill Brook and convey it to the purification works, the Mill Brook channel being retained to carry the natural flow of the brook and the excess of flow in the intercepting sewers at times of storm directly to the Blackstone River.

At the present time, in addition to the precipitation works, there are about 10 acres of filter beds, on which a portion of the effluent from the precipitation works is discharged. Additional filter beds are now being constructed. During the year 1902, 12,500,000 gallons of sewage per day were treated at the purification works; and the accompanying table, taken from the report of the superintendent of sewers of the city of Worcester for the year ending Nov. 30, 1902, shows the purification effected during each month of the year: —

COMBINED RESULTS OF SEWAGE TREATMENT. — MONTHLY AVERAGES OF WEEKLY ANALYSES OF DAILY SAMPLES.

[Parts per 100,000.]

DATE OF COLLECTION.	AMMONIA.				OXYGEN CONSUMED.		Chlorine.	Average Flow per Day in Million Gallons.
	Free.	ALBUMINOID.			Un-filtered.	Filtered.		
		Total.	Dissolved.	Sus-pended.				
Sewage, December, 1901, . .	1.470	.674	.196	.478	9.43	7.23	5.64	12.40
Effluent, December, 1901, .	1.312	.327	.327	.000	3.86	3.52	5.68	
Per cent. removed, . .	10.75	51.47	—66.83	100.00	59.07	51.33	-	
Sewage, January, 1902, .	1.717	.703	.232	.471	10.26	7.28	6.26	10.38
Effluent, January, 1902, .	1.348	.300	.300	.000	3.70	3.47	6.19	
Per cent. removed, . .	21.49	57.32	—29.31	100.00	63.95	52.34	-	
Sewage, February, 1902, .	2.528	.895	.343	.552	12.63	7.70	7.44	11.33
Effluent, February, 1902, .	1.945	.445	.381	.064	5.72	4.72	7.55	
Per cent. removed, . .	23.06	50.28	—11.08	88.41	54.71	38.70	-	
Sewage, March, 1902, . .	1.256	.571	.186	.385	8.29	5.18	7.20	15.97
Effluent, March, 1902, . .	1.083	.332	.202	.130	3.61	2.91	5.78	
Per cent. removed, . .	13.77	41.86	—8.60	66.22	56.44	43.82	-	
Sewage, April, 1902, . .	1.535	.501	.175	.326	9.67	6.16	6.51	16.51
Effluent, April, 1902, . .	1.249	.301	.250	.051	3.95	3.06	6.16	
Per cent removed, . .	18.67	39.92	—42.86	84.35	59.16	50.32	-	
Sewage, May, 1902, . .	2.302	.769	.247	.522	11.13	6.97	8.77	13.77
Effluent, May, 1902, . .	1.750	.354	.299	.055	4.50	4.10	8.46	
Per cent. removed, . .	23.97	53.96	—21.05	89.46	59.60	41.18	-	
Sewage, June, 1902, . .	2.431	.941	.250	.691	13.27	8.28	10.12	11.19
Effluent, June, 1902, . .	2.113	.408	.386	.022	4.37	3.95	10.29	
Per cent. removed, . .	13.08	56.63	—54.41	96.81	67.07	52.30	-	

COMBINED RESULTS OF SEWAGE TREATMENT.—MONTHLY AVERAGES OF WEEKLY ANALYSES OF DAILY SAMPLES—*Concluded.*

[Parts per 100,000.]

DATE OF COLLECTION.	AMMONIA.				OXYGEN CONSUMED.		Chlorine.	Average Flow per Day in Million Gallons.
	Free.	ALBUMINOID.			Un-filtered.	Filtered.		
		Total.	Dissolved.	Sus-pended.				
Sewage, July, 1902, . .	2.437	1.041	.292	.749	12.45	7.08	10.87	10.00
Effluent, July, 1902, . .	1.989	.383	.350	.033	3.45	3.09	10.77	
Per cent. removed, . .	18.39	63.22	—19.86	95.57	72.30	56.36	-	
Sewage, August, 1902, .	2.391	.969	.307	.662	11.81	6.82	10.62	10.75
Effluent, August, 1902, .	2.042	.452	.400	.052	4.13	3.73	10.71	
Per cent. removed, . .	14.60	53.35	—30.30	92.12	65.03	45.31	-	
Sewage, September, 1902, .	2.694	1.065	.356	.709	12.72	7.18	10.65	10.76
Effluent, September, 1902, .	2.586	.488	.412	.076	4.45	3.64	11.10	
Per cent. removed, . .	4.01	54.18	—15.73	89.29	65.01	49.30	-	
Sewage, October, 1902, .	2.272	.973	.266	.707	11.48	6.41	9.89	13.29
Effluent, October, 1902, .	2.036	.396	.340	.056	3.95	3.42	9.61	
Per cent. removed, . .	10.39	59.30	—27.82	92.08	65.60	46.65	-	
Sewage, November, 1902, .	2.225	.869	.250	.619	11.10	6.71	9.18	14.20
Effluent, November, 1902, .	2.163	.462	.368	.094	4.69	4.27	9.51	
Per cent. removed, . .	2.79	46.84	—32.00	84.82	57.76	36.37	-	
Average sewage, 1902, .	2.059	.810	.252	.558	11.02	6.83	8.43	12.54
Average effluent, 1902,	1.763	.383	.327	.056	4.10	3.54	7.05	
Per cent. removed, .	14.37	52.74	—29.77	89.99	62.81	48.19	-	

NOTE.—This table is made up of monthly averages of analyses of sewage, the effluent from chemical precipitation alone, and from precipitation followed by filtration, combined by calculation according to the flow treated by each of the two methods.

The effluent from the precipitation works is discharged into the river about a mile below the junction of Mill and Kettle brooks, and the river below this point is a very foully polluted stream, and is exceedingly offensive.

The village of Millbury is situated about 3 miles below the Worcester precipitation works, and the several mill ponds on the river contain an accumulation of organic matter, and are very offensive. Within the town of Millbury the river receives the flow from Singletary Brook, on which there are several mills. There are also several factories on the main river in this village. Altogether there are about fifteen factories in Millbury, employing 900 persons, and the sewage from 675 of these is discharged directly into the stream. Many of the factories do not produce objectionable wastes, but there are two woolen mills from which large quantities of wool-scouring wastes are discharged into the stream. The character of the river improves in passing through Millbury, notwithstanding the sewage and manufacturing wastes discharged into it.

In Sutton, the next town through which the river passes, there are several mill privileges, but no factories which are now in operation.

In the village of Saundersville, in Grafton, there is a cotton mill employing 175 persons, from which the sewage is discharged into the stream. The river is joined at this point by the Quinsigamond River, on which there are several mills within the town of Grafton, the principal wastes being from a flax mill and a shoe shop. None of the sewage from these mills is discharged directly into the stream. The effect of the purer water of the Quinsigamond River upon the water of the Blackstone River is very noticeable, and the condition of the river below Saundersville is much less objectionable than it is above that village.

Just below the junction of the Quinsigamond and Blackstone rivers, at Fisherville, in the town of Grafton, there is a large cotton mill employing from 400 to 500 persons, the sewage from which overflows from a cesspool into the river, but no manufacturing wastes are discharged into the stream.

At Rochdale, in the town of Northbridge, there is a cotton mill employing 600 persons, but no considerable quantities of sewage or wastes are discharged into the river at this point.

At Riverdale, in Northbridge, the river receives sewage and large quantities of wastes from a shoddy mill employing 60 persons.

At Uxbridge, the Calumet Woolen Company's mills discharge the sewage from 385 persons, and wastes from scouring 6,000 pounds of wool daily and from washing and dyeing the finished product, into the stream.

A short distance below the Calumet Woolen Mills the river is joined from the west by the Mumford River, which flows through the village of Manchaug in the town of Sutton, the town of Douglas, and the villages of Whitinsville and Linwood in the town of Northbridge. In Manchaug and Douglas there are three factories, employing together about 1,000 persons, nearly all of the sewage being discharged into the stream. The Manchaug mill is a cotton mill employing over 500 persons, and those in Douglas are a tool factory and a woolen mill. At the cotton mill and the tool factory there are no wastes discharged into the river; but at the woolen mill a small quantity of wool is scoured, and the wastes from this, together with the wastes from washing and dyeing the finished product, are discharged into the river.

At Whitinsville the Mumford River receives a small quantity of wastes from large machine works and from a cotton mill. The village of Whitinsville contains a large population and is provided with a water supply, but it is as yet unprovided with a complete sewerage system. Sewers have been constructed which receive the sink drainage from a large proportion of the houses, and discharge directly into the river, and there are a few water-closets in dwelling-houses and in the factories which discharge directly into the river. Plans have been prepared for the sewerage of this village, the sewage to be purified by sand filtration. The Mumford River below Whitinsville is quite noticeably polluted.

In Uxbridge the Mumford River receives the sewage and wastes from three mills, employing about 175 persons, the wastes consisting of wool-scouring liquor, spent dyes and water used for washing cloth.

Just below the junction of the Mumford River with the Blackstone there is a large tributary known as the West River, on which, in the village of Wheelock, is situated a mill employing about 60 persons, the sewage and wastes from which are discharged directly into the river. The wastes from this mill consist of water used for washing cloth and for fulling.

A small tributary enters the river just below the West River, on which is a satinet mill, which discharges the sewage from 75 operatives and the water used for washing cloth and for fulling cloth into the stream.

In the town of Blackstone there are two large cotton factories, one situated in the village of Millville, employing 100 persons, and the other in the village of Blackstone, employing 460 persons, and a rubber factory in the village of Millville, employing 750 persons, the sewage from which, together with a comparatively small quantity of manufacturing waste, is discharged into the river. The town of Blackstone is not provided with a sewerage system, but a large quantity of sink drainage and considerable sewage is discharged into the river through private sewers.

The character of the Blackstone River is well shown by the table of averages of chemical analyses which follows. It will be seen that the river below Worcester contains about as much organic matter as the sewage flowing from some sewerage systems, but the character of the water improves considerably, due chiefly to sedimentation and dilution. When it reaches the State line at Blackstone, however, it is still highly polluted, and has an objectionable odor in the drier portion of the year.

The Blackstone River is joined in Rhode Island, a short distance below the State line, by Mill River, the drainage area of which is 33.7 square miles, chiefly in Massachusetts. The only serious sources of pollution upon it are in the town of Hopedale, 10 miles above its mouth.

Hopedale had in 1900 a population of 2,087. It is provided with a system of separate sewers, the sewage being collected in a tank and pumped to the filter beds. A considerable portion of the sewage, however, is at times discharged from the tank directly into the river.

Besides the sewage, the river receives at Hopedale a large amount of acid wastes from a factory where cotton machinery is manufactured. The river below the village is at times very noticeably polluted.

CHEMICAL EXAMINATION OF WATER FROM THE BLACKSTONE RIVER. — AVERAGES FOR SIX MONTHS, FROM JUNE TO NOVEMBER, 1887 TO 1902, INCLUSIVE.

Blackstone River, between Mill Brook Channel and the Sewage Precipitation Works of the City of Worcester.

[Parts per 100,000.]

Months.	Color.	Residue on Evaporation.		Free Ammonia.	Albuminoid Ammonia.			Chlorine.	Nitrogen as		Hardness.
		Total.	Loss on Ignition.		Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.	
June-Nov., 1887, . .	.91	-	-	.2686	.1741	-	-	1.35	.0160	-	-
" " 1888, . .	.76	-	-	.2658	.1112	.0557	.0555	1.50	.0382	.0041	-
" " 1889, . .	.86	-	-	.3980	.1430	.0772	.0658	1.32	.0177	.0026	-
" " 1890, . .	1.14	9.92	3.03	.2107	.1246	.0673	.0573	1.07	.0250	.0015	2.9
" " 1891, . .	1.10	17.42	5.59	.4913	.1950	.1127	.0823	2.29	.0192	.0037	5.0
" " 1892, . .	.52	20.75	6.30	.3547	.1433	.0708	.0725	2.43	.0227	.0108	6.1
" " 1893, . .	.40	16.98	4.55	.1480	.0588	.0240	.0348	1.01	.0115	.0015	6.3
" " 1894, . .	.66	16.93	4.76	.0548	.0380	.0236	.0144	.74	.0115	.0005	4.4
" " 1895, . .	.49	14.17	4.50	.0613	.0414	.0243	.0171	.92	.0163	.0006	3.4
" " 1896, . .	.51	12.90	2.93	.0780	.0415	.0282	.0133	.97	.0147	.0015	3.4
" " 1897, . .	.85	26.45	7.68	.1130	.0674	.0362	.0312	.89	.0090	.0024	4.2*
" " 1898, . .	.33	17.42	5.62	.0857	.0619	.0260	.0359	.96	.0053	.0010	4.6
" " 1899, . .	.14*	34.38	10.60	.2583	.0788	.0390	.0398	1.55†	.0050†	.0004	14.3
" " 1900, . .	.05	16.48	3.38	.1068	.0518	.0210	.0308	1.03	.0107	.0012	3.6
" " 1901, . .	.23	31.03	11.68	.1410	.0548	.0309	.0239	-	-	.0023	13.8
" " 1902, . .	.10	46.15	12.47	.2453	.0728	.0274	.0454	-	-	.0010	16.5

Blackstone River, below Sewage Precipitation Works.

June-Nov., 1887, . .	.91	-	-	.2686	.1741	-	-	1.35	.0160	-	-
" " 1888, . .	.76	-	-	.2658	.1112	.0557	.0555	1.50	.0382	.0041	-
" " 1889, . .	.86	-	-	.3980	.1430	.0772	.0658	1.32	.0177	.0026	-
" " 1890, . .	.97	11.36	3.10	.2907	.1492	.0722	.0770	1.46	.0270	.0018	3.9
" " 1891, . .	1.05	22.25	6.60	.6367	.1508	.0883	.0625	2.61	.0233	.0040	6.2
" " 1892, . .	.63	26.80	7.75	.5240	.1810	.0958	.0852	3.13	.0137	.0050	10.3
" " 1893, . .	.51	30.00	7.13	.5680	.1453	.0900	.0553	2.76	.0285	.0126	10.9
" " 1894, . .	.40	29.30	5.86	.6189	.1390	.1113	.0277	2.63	.0212	.0071	10.6
" " 1895, . .	.71	22.15	5.18	.3246	.0898	.0597	.0301	1.86	.0267	.0063	7.3
" " 1896, . .	.30	26.03	6.53	.2831	.0898	.0600	.0298	2.10	.0217	.0118	9.7
" " 1897, . .	.73	25.98	4.97	.3650	.1122	.0782	.0340	1.61	.0207	.0063	6.9
" " 1898, . .	.23	25.63	6.73	.3064	.0868	.0560	.0308	1.55	.0132	.0119	9.2
" " 1899, . .	.14*	44.02	9.67	.5251	.1707	.0912	.0795	3.26	.0108*	.0068	16.1
" " 1900, . .	.22	24.57	4.48	.4430	.1249	.0621	.0628	2.13	.0110	.0145	7.3
" " 1901, . .	.09	31.12	6.90	.4580	.1293	.0772	.0521	3.42	.0090	.0058	10.8
" " 1902,* . .	.15	49.62	13.38	.7296	.1284	.0736	.0548	2.97	-	.0033	12.5

* Average of five months. † Average of two months.

CHEMICAL EXAMINATION OF WATER FROM THE BLACKSTONE RIVER, ETC. — *Concluded.*

Blackstone River, at Uxbridge.

[Parts per 100,000.]

MONTHS.	Color.	RESIDUE ON EVAPORATION.		Free Ammonia.	ALBUMINOID AMMONIA.			Chlorine.	NITROGEN AS		Hardness.
		Total.	Loss on Ignition.		Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.	
June-Nov., 1887,	.39	-	-	.1129	.0271	-	-	.79	.0360	-	-
“ “ 1888,	.38	6.42	1.52	.1155	.0288	.0222	.0066	.68	.0310	.0007	-
“ “ 1889,	.32	-	-	.1133	.0296	.0192	.0104	.66	.0333	.0009	-
“ “ 1890,	.26	8.86	2.12	.1629	.0231	.0174	.0057	.79	.0259	.0005	2.9
“ “ 1891,	.20	10.16	2.61	.2280	.0175	.0117	.0058	1.04	.0425	.0007	3.6
“ “ 1892,	.13	9.36	1.88	.2840	.0227	.0162	.0065	.99	.0313	.0007	3.1
“ “ 1893,	.24	11.74	2.37	.1985	.0207	.0140	.0067	1.20	.0623	.0050	4.2
“ “ 1894,	.35	13.07	2.03	.1456	.0243	.0183	.0060	1.57	.0673	.0050	4.9
“ “ 1895,*	.56	12.95	2.69	.0906	.0258	.0182	.0076	1.34	.0631	.0065	4.7
“ “ 1896,	.33	12.68	2.67	.1129	.0257	.0221	.0036	1.38	.0477	.0091	5.0
“ “ 1897,	.48	11.60	2.47	.1029	.0280	.0215	.0065	1.32	.0652	.0051	4.3
“ “ 1898,	.49	10.59	2.78	.0801	.0264	.0219	.0045	1.00	.0470	.0076	3.8
“ “ 1899,	.18	18.34	3.11	.2490	.0359	.0310	.0049	2.17	.0510	.0141	7.4
“ “ 1900,	.19	13.42	2.04	.2260	.0347	.0257	.0090	1.76	.0558	.0060	5.0
“ “ 1901,	.22	13.91	2.67	.3159	.0285	.0240	.0045	1.50	.0195	.0035	5.0
“ “ 1902,	.15	14.17	2.56	.3462	.0270	.0218	.0052	1.95	.0210	.0018	4.9

Blackstone River, at Millville.

June-Nov., 1887,	.31	-	-	.0468	.0220	-	-	.51	.0210	-	-
“ “ 1888,	.41	5.22	1.40	.0467	.0296	.0233	.0063	.50	.0278	.0004	-
“ “ 1889,	.38	-	-	.0499	.0273	.0213	.0060	.45	.0167	.0003	-
“ “ 1890,	.26	6.71	2.24	.0736	.0196	.0152	.0044	.53	.0229	.0003	2.3
“ “ 1891,	.24	7.48	2.35	.1105	.0384	.0234	.0150	.72	.0308	.0006	2.2
“ “ 1892,	.37	6.70	1.62	.1143	.0294	.0210	.0084	.63	.0217	.0002	2.0
“ “ 1893,	.23	7.43	1.73	.0677	.0119	.0087	.0032	.77	.0385	.0011	2.6
“ “ 1894,	.47	8.42	2.16	.0510	.0172	.0139	.0033	.89	.0273	.0012	2.8
“ “ 1895,	.51	8.67	2.55	.0356	.0233	.0180	.0053	.90	.0383	.0024	3.2
“ “ 1896,	.35	8.53	1.69	.0484	.0237	.0180	.0057	.97	.0413	.0027	3.3
“ “ 1897,	.45	7.66	1.98	.0509	.0258	.0210	.0048	.92	.0445	.0019	3.1
“ “ 1898,	.51	7.12	2.17	.0325	.0240	.0193	.0047	.63	.0240	.0023	2.5
“ “ 1899,	.20	12.50	2.44	.1310	.0301	.0247	.0054	1.31	.0310	.0049	4.6
“ “ 1900,	.29	9.33	1.82	.1168	.0254	.0219	.0035	1.15	.0417	.0039	3.4
“ “ 1901,	.31	8.62	2.13	.1420	.0288	.0227	.0061	.87	.0155	.0006	3.1
“ “ 1902,	.28	9.43	2.24	.1623	.0284	.0238	.0046	1.20	.0195	.0010	2.8

* Average of five months.

NOTE. — The sewage purification works of the city of Worcester were put in operation in 1890, since which time a portion of the sewage of the city has been treated. The works were enlarged in 1893, and since that time practically all of the dry-weather flow of sewage has been treated.

CHARLES RIVER.

The Charles River rises in the town of Milford, and flows in a generally north-easterly direction, discharging into Boston harbor. Throughout the upper and lower portions of its course the river has considerable fall, much of which is utilized to furnish power for factories; but there are stretches of many miles through the central portion of its course where the stream flows through extensive meadows with a sluggish current.

At Dedham a portion of the flow, amounting ordinarily to about one-third of the total flow at that point, is diverted into the Neponset River through the Mother Brook channel. Water for the supply of the towns of Dedham and Brookline and the cities of Newton, Waltham and Cambridge is taken from the water-shed of the Charles River, and much of it is not returned to the river, as in all these places the sewage is taken out of the water-shed.

The following tables give data relating to the drainage areas at the various places, and the populations upon them: —

LOCALITY.	Distance Above Mouth (Miles).	Drainage Area (Square Miles).	Population on Drainage Area.	Population per Square Mile.	Population discharging Sewage or Sewage Effluent into River.
Below Milford,	64.5	10.7	9,100	850	2,000
At South Natick,	37.0	156.0	31,100	199	4,430
Just above Mother Brook,	24.7	198.6	41,600	210	4,430
Just below Mother Brook,	24.7	132.4*	27,700	209	4,430
At Brookline water works pumping station,	22.5	134.5	32,700	243	4,430
At Newton water works pumping station,	19.7	142.4	36,600	257	4,430
At Waltham water works pumping station,	12.5	183.8	49,700	270	4,880
At lowest dam, Watertown,	8.2	207.8	98,400	473	4,900
At Craigie bridge,	0	307.5	-	-	-

* Allowing for the diversion of the water of one-third of the river into Mother Brook and the Neponset River.

CITIES AND TOWNS, CONSIDERABLE PORTIONS OF WHICH ARE WITHIN THE WATER-SHED OF THE CHARLES RIVER.

CITY OR TOWN.	Population in 1900.	Sewerage System.	Estimated Population discharging Sewage or Sewage Effluent into River.	Manufactories discharging Wastes into River.
Milford,	11,376	Partial.	2,000	One rubber factory, one shoe shop.
Bellingham,	1,682	None.	300	One woolen mill, one satinet mill.
Holliston,	2,598	None.	50	One woolen mill.

CITIES AND TOWNS, CONSIDERABLE PORTIONS OF WHICH ARE WITHIN THE WATER-SHED OF THE CHARLES RIVER — *Concluded.*

CITY OR TOWN.	Population in 1900.	Sewerage System	Estimated Population discharging Sewage or Sewage Effluent into River.	Manufactories discharging Wastes into River.
Medway,	2,761	Private sewers.	200	One woolen mill.
Franklin,	5,017	Partial.*	1,500	One felt mill, one linen mill, one rubber mill, four woolen mills.
Wrentham,	2,720	None.	0	None.
Norfolk,	980	None.	150	Three paper mills, two shoddy mills, one felt mill.
Millis,	1,053	None.	30	One felt mill.
Medfield,	2,926	Partial.*	200	None.
Sherborn,	1,483	None.	0	None.
Dover,	656	None.	0	None.
Natick,	9,488	General.*	0	None.
Needham,	4,016	None.	0	None.
Dedham,	7,457	General.†	0	None.
Wellesley,	5,072	None.	0	One hosiery mill, one shoddy mill.
Newton,	33,587	General.†	450	One machine shop, one dye house, one silk mill, one paper mill, one shoddy mill.
Lincoln,	1,127	None.	0	None.
Weston,	1,834	None.	0	None.
Waltham,	23,481	General.†	0	One watch factory, one cotton mill, one bleachery, one gas works.
Watertown,	9,706	General †	0	One woolen mill, one paper mill, one dye works, one gas works.
Brookline,	19,935	General.†	0	None.
Cambridge,	91,886	General.†	0	None.

* Purification works in use. † Connected with metropolitan sewerage system.

Above the village of Milford the river is used as a source of water supply for the towns of Milford and Hopedale, the water being passed through sand filters before being supplied to consumers.

In Milford the stream receives the sewage from the principal part of the village, besides sewage and manufacturing wastes from several factories, the principal one being a shoe shop employing 400 persons.

The population of Milford in 1900 was 11,376, and it is estimated that the sewage of about 2,000 persons is discharged into the river.

The sewers have not been constructed in accordance with any general plan, but have been built from time to time, and they receive both sewage and storm water. There are two points of discharge, the upper one being in the midst of a densely populated section, at a point where at times no water is flowing in the river, all of the water being diverted from the mill pond above, through a canal and tail-race. This outlet has given so much trouble that a settling tank was constructed through which the sewage was to pass before being discharged into the river, and a pipe was laid to carry the dry-weather flow of sewage to another outlet into the river below the tail-race. The pipe through which the dry-weather flow of sewage was to be carried has become broken, and the sewage is still discharged at the old outlet, causing a great nuisance in the vicinity.

The lower outlet is at a highway bridge near a large factory, about a quarter of a mile below the upper outlet, and the conditions about this outlet also are very objectionable. A tank has been constructed on the line of the main sewer, through which the sewage is passed for the purpose of removing a portion of the solid matter, but it is not operated in such a manner as to have any noticeable effect on the character of the sewage discharged into the stream.

The Charles River for a distance below Milford is exceedingly foul, but it flows through a territory which, except immediately below the outlet, is sparsely inhabited, and at Bellingham, five miles below the sewer outlet, the condition of the river is very much improved.

In Bellingham there is a small shoddy mill, the sewage from which goes into the river, but no liquid wastes are produced. At North Bellingham, about 2½ miles below Bellingham, there is a woolen mill employing about 140 persons, sewage from which is discharged into the river, together with wastes from dyeing and from the washing and fulling of cloth. At Careyville in the town of Bellingham, near the Medway line, there is a large satinet and cashmere mill employing about 190 persons, sewage and wastes from which are all discharged into the river.

At Medway there is a small woolen mill employing 85 persons, from which sewage and wastes, consisting of wool-scouring liquor, spent dyes and water used for washing the goods, are discharged into the river.

Mine Brook, which enters the Charles River at Medway, drains the westerly section of the town of Franklin. On this brook there are eight factories, including five woolen mills, wastes from which, together with the sewage from 415 operatives, are discharged into the stream. Mine Brook below Franklin is exceedingly foul, and at times the water is almost opaque. The water supply of Franklin is taken in part from Beaver Pond, a tributary of Mine Brook, and at times of high water the water of Mine Brook flows into the pond.

In the village of Rockville in Millis, the next town below Medway, the river receives sewage and a small amount of waste from a felt mill employing 35 persons. Just above Rockville the Charles River receives the flow of Mill River, a branch which rises in Wrentham and drains sections of that town and of Franklin and Norfolk. This stream receives the effluent from the sewage purification works at Franklin.

The town of Franklin had in 1900 a population of 5,017. It is situated between Mine Brook, which enters the Charles River at West Medway, and Mill River, which enters it about 5 miles below Mine Brook. The principal factories from which large quantities of wastes are discharged are on the water-shed of Mine Brook, but the sewage of the town is disposed of in the water-shed of the other stream.

The sewage from a small section of the village is conveyed to purification works, which consist of sand filter beds; but the sewage is discharged upon the beds continuously, and the beds receive little care and the sewage is very imperfectly purified. The quantity of sewage treated at the works amounts to about 5,000 gallons per day. There is considerable unpurified sewage which enters Mill River both from factories and from dwelling houses through private sewers, and there is a considerable quantity of manufacturing waste from a felt mill and a hat factory, which discolors the water.

Mill River also receives sewage and wastes from a felt mill and a paper mill, and sewage from a shoddy mill, employing together about 115 persons, all of which are within the town of Norfolk.

About 4 miles below Rockville the Charles River is joined by Stop River, which flows through a portion of the town of Norfolk, and on which are located a paper mill employing 13 persons and a shoddy mill employing about 25 persons, the sewage and wastes from which are discharged into the river.

In Medfield the river receives the effluent from the sewage purification works of the town.

The town of Medfield had in 1900 a population of 2,926, and a portion of the main village, including a large straw shop, is provided with sewers, the sewage being purified by intermittent filtration on prepared beds of sand. The sewage consists chiefly of wastes from the straw shop, and the quantity purified amounts to about 90,000 gallons per day. The numerous examinations which have been made indicate that the sewage is very thoroughly purified.

In the upper portion of Boggistere Brook in Holliston the sewage and wastes from a woolen mill employing 60 persons are discharged into the stream. At this factory no wool is scoured, but cloth is washed and dyed.

At South Natick the river receives a small amount of sewage from the electric light station; and at Charles River Village in Needham, four miles below South Natick, there is a paper mill, which is not at the present time in operation.

Between Charles River Village and Newton Upper Falls there are no factories, and the river has but very little fall throughout most of its course, being bordered through much of the distance by extensive meadows. At Newton Upper Falls and Newton Lower Falls there are two shoddy mills, a paper mill, a silk mill, a glue works and a machine shop, from all of which wastes are discharged into the stream, the most objectionable waste apparently coming from the silk mill and from the shoddy and paper mills. At these factories also the sewage from about 450 persons is discharged into the stream. In the immediate vicinity of several of these factories the river is noticeably polluted at times of low flow.

In Waltham the river receives a small amount of waste from a watch factory and from a cotton mill, and considerable waste from a bleachery. The sewage from the operatives at these mills is taken into the city sewers.

At Watertown a portion of the wastes from a woolen mill and large quantities of wastes from a paper mill and dye works are discharged into the stream. Wastes from gas factories are discharged into the stream at both Waltham and Watertown. Below Watertown the river is a tidal stream.

Within the city of Boston the river receives sewage directly from about 1,000 persons, and in Boston and Cambridge it receives, at times of storm, sewage mixed with a certain amount of storm water from numerous overflows along the river and its tributaries. Stony Brook, a tributary which drains a thickly populated section of Boston, also receives directly a considerable quantity of sewage and the wastes from several breweries.*

As before stated, approximately one-third of the flow of the river is diverted at Dedham into the Neponset River. The towns of Dedham, Watertown and Brookline, and the cities of Newton, Waltham, Cambridge and Boston, are provided with sewerage systems, the sewage, excepting a portion which overflows at times of storm, being conveyed outside of the water-shed. All of these places except Boston and Watertown are supplied with water taken from the water-shed of the Charles River; and, as the sewage is removed from the water-shed, the flow of the river is somewhat reduced. The average daily quantity of water used by the cities and towns taking water from the river was 15,000,000 gallons in 1902.

A special examination of the river at Milford and for several miles below Milford was made during the summer of 1902, the results of which are presented in the following table. The results of the analyses of samples collected at various points during the months of low flow for several years are also presented. It will be seen that the river below Milford is a foully polluted stream, but the water of the river rapidly improves, and opposite the Brookline and Newton pumping stations there is but little evidence of pollution. The river in the lower portion of its course, except at those places in the immediate vicinity of certain factories, from which manufacturing wastes are discharged into the stream, is entirely unobjectionable to sight and smell.

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* See pages 290 and 310.

SPECIAL EXAMINATION OF CHARLES RIVER, NEAR MILFORD, JULY 10 AND 11, 1902.

[Parts per 100,000.]

SOURCE.	DAY SAMPLE.				NIGHT SAMPLE.			
	Free Ammonia.	Albuminoid Ammonia.	Chlorine.	Dissolved Oxygen.	Free Ammonia.	Albuminoid Ammonia.	Chlorine.	Dissolved Oxygen.
Charles River, above sewer outlets, Milford, .	.0210	.0420	.31	70.2	-	-	-	-
Main Street sewer outlet, ...	1.7300	.5500	27.7	-	1.2100	.2200	6.00	-
Central Street sewer outlet, ...	2.3900	.6800	6.50	-	1.2300	.3300	5.40	-
Charles River, ¼ mile below Central Street, .	.7100	.1540	4.13	18.3 4.9	.4600	.1045	2.56	5.3 11.6
Charles River, 1 mile below Central Street, .	.4200	.0535	1.84	18.8 13.5	.2960	.0770	1.85	4.2 9.3
Charles River, 2 miles below Central Street, .	.1656	.0457	1.45	28.3 38.2	.1300	.0505	1.21	13.3 11.8
Charles River, 3 miles below Central Street (outlet of pond at South Milford).	.0710	.0480	1.21	72.4 100.0	.0247	.0470	1.12	68.7 6.4
Charles River, 5 miles below Milford, . . .	.0098	.0314	0.86	67.7 91.0	.0078	.0364	.74	72.5 40.9

Flow of sewage from Main Street sewer, Milford, 60,000 gallons per day.
Flow of sewage from Central Street sewer, Milford, 72,000 gallons per day.
Flow of river at Milford, 5.9 cubic feet per second.

CHEMICAL EXAMINATION OF WATER FROM THE CHARLES RIVER. — AVERAGES FOR SIX MONTHS, FROM JUNE TO NOVEMBER, INCLUSIVE.

Charles River, above Milford.

[Parts per 100,000.]

YEAR.	Color.	RESIDUE ON EVAPORATION.		AMMONIA.				Chlorine.	NITROGEN AS		Oxygen Consumed.	Hardness.
					ALBUMINOID.							
		Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		
1899, ...	.28	3.98	1.70	.0017	.0248	.0223	.0025	.27	.0027	.0003	.48	.6
1900, ...	.49	3.93	1.67	.0017	.0251	.0231	.0020	.25	.0030	.0000	.64	.5
1901, ...	.46	4.30	2.48	.0066	.0286	.0247	.0039	.25	.0060	.0002	.65	.6
1902, ...	.58	4.42	1.90	.0025	.0248	.0210	.0038	.29	.0057	.0001	.70	1.1

Charles River, below Milford.

1898, ...	.63	10.47	3.08	.1195	.0597	.0422	.0175	2.47	.0473	.0064	.69	2.4
1899, ...	.50	12.52	3.12	.3487	.1345	.0803	.0542	3.00	.0053	.0008	1.12	2.6
1900, ...	.56	12.85	2.65	.7123	.0764	.0563	.0201	2.74	.0140	.0055	.93	3.1
1901, ...	.63	9.52	3.37	.1419	.0451	.0317	.0134	1.40	.0422	.0048	.86	2.6
1902, ...	.52	10.74	3.38	.2118	.0658	.0406	.0252	2.21	.0236	.0049	1.02	2.7

CHEMICAL EXAMINATION OF WATER FROM THE CHARLES RIVER. — AVERAGES FOR SIX MONTHS, FROM JUNE TO NOVEMBER, INCLUSIVE — *Concluded.*

Charles River, at Bellingham.

[Parts per 100,000.]

YEAR.	Color.	RESIDUE ON EVAPORATION.		AMMONIA.				Chlorine.	NITROGEN AS		Oxygen Consumed.	Hardness.
					ALBUMINOID.							
		Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Sus-pended.		Nitrates.	Nitrites.		
1902, ...	.51	6.98	2.60	.0129	.0307	.0278	.0029	1.10	.0270	.0016	.64	2.0

Charles River, at Needham.

1899, ...	.47	5.29	1.97	.0006	.0257	.0239	.0018	.43	.0032	.0000	.64	1.6
1900, ...	.60	4.92	1.68	.0011	.0249	.0234	.0015	.44	.0033	.0000	.71	1.2
1901, ...	.96	5.26	2.61	.0024	.0294	.0272	.0022	.39	.0058	.0001	.97	1.5
1902, ...	.60	5.24	1.93	.0039	.0271	.0249	.0022	.54	.0042	.0001	.66	1.6

Charles River, opposite Brookline Water Works Pumping Station.

1887, ...	.83	5.37	1.62	.0013	.0282	–	–	.44	.0087	–	–	–
1888, ...	.98	4.87	1.92	.0014	.0264	.0240	.0024	.37	.0062	.0002	–	–
1895, ...	.74	4.91	2.08	.0004	.0237	.0207	.0030	.48	.0055	.0001	.75	1.5
1897, ...	1.02	5.36	2.45	.0012	.0288	.0262	.0026	.43	.0067	.0001	.86	1.5
1898, ...	.87	5.22	2.40	.0012	.0303	.0281	.0022	.39	.0035	.0001	.92	1.4
1899, ...	.46	5.03	1.92	.0011	.0262	.0230	.0032	.45	.0025	.0001	.62	1.5
1900, ...	.56	4.96	1.60	.0018	.0252	.0229	.0023	.46	.0020	.0000	.70	1.4
1901, ...	.92	5.45	2.60	.0020	.0314	.0275	.0039	.41	.0047	.0001	.95	1.4
1902, ...	.52	5.46	2.03	.0031	.0234	.0211	.0023	.57	.0045	.0001	.64	1.6

Charles River, opposite Newton Water Works Pumping Station.

1887, ...	.73	5.53	1.49	.0008	.0267	–	–	.45	.0033	–	–	–
1888, ...	1.03	5.02	2.00	.0012	.0291	.0269	.0022	.37	.0075	.0002	–	–
1897, ...	1.20	6.75	2.87	.0041	.0337	.0302	.0035	.49	.0093	.0001	.99	2.2
1898, ...	.92	5.36	2.51	.0017	.0327	.0298	.0029	.42	.0035	.0001	.97	1.7

Charles River, opposite Waltham Water Works Pumping Station.

1887, ...	.67	6.02	1.62	.0029	.0274	–	–	.48	.0043	–	–	–
1888, ...	.82	5.47	1.88	.0035	.0310	.0265	.0045	.41	.0087	.0002	–	–
1897, ...	.95	6.06	2.45	.0056	.0322	.0299	.0023	.53	.0073	.0002	.83	1.9
1898, ...	.81	5.74	2.46	.0050	.0329	.0296	.0033	.44	.0043	.0001	.85	1.6
1899, ...	.41	5.50	1.81	.0047	.0264	.0248	.0016	.51	.0051	.0002	.52	1.9
1900, ...	.52	5.93	1.68	.0064	.0282	.0259	.0023	.53	.0070	.0002	.58	1.7
1901, ...	.82	5.93	2.72	.0065	.0322	.0289	.0033	.44	.0067	.0002	.85	1.8
1902, ...	.45	6.21	1.97	.0084	.0258	.0228	.0030	.62	.0077	.0003	.59	2.0

Charles River, opposite Watertown Water Works Pumping Station.

1887, ...	.57	7.11	1.57	.0086	.0268	–	–	.69	.0234	–	–	–
1888, ...	.86	6.75	2.25	.0051	.0335	.0285	.0070	.61	.0320	.0010	–	–
1893, ...	.57	7.02	2.03	.0083	.0244	.0202	.0042	.70	.0242	.0006	.55	2.4

CHICOPEE RIVER.

The Chicopee River is formed by the junction of the Swift, Ware and Quaboag rivers below Palmer, whence it flows in a westerly direction, and discharges into the Connecticut River a short distance above Springfield.

The following tables give statistics in regard to the drainage areas and populations upon them at various places: —

Locality.	Distance above Mouth (Miles).	Drainage Area (Square Miles).	Population on Drainage Area.	Population per Square Mile.	Estimated Population discharging Sewage or Sewage Effluent into River.
Swift River, at mouth, ...	18.1	218.0	7,700	35	900
Ware River, just below Ware, . . .	28.2	192.4	13,700	71	8,000
Ware River, at mouth, ...	17.5	223.2	18,000	81	8,700
Seven Mile River,* just below Spencer, .	45.5	30.6	7,300	238	6,500
Quaboag River, at mouth, ...	17.5	213.5	28,400	133	10,450
Chicopee River, at Ludlow, ...	8.8	694.9	59,100	85	22,750
Chicopee River, at mouth, ...	0.0	730.4	77,700	106	39,650

* A tributary of the Quaboag.

CITIES AND TOWNS, CONSIDERABLE PORTIONS OF WHICH ARE WITHIN THE WATER-SHED OF THE CHICOPEE RIVER.

City or Town.	Population in 1900.	Sewerage System.	Estimated Population discharging Sewage or Sewage Effluent into River.	Manufactories discharging Wastes into River.
Petersham, . .	853	None.	0	None.
New Salem, . .	807	None.	0	None.
Dana, . . .	790	None.	0	One satinet mill.
Shutesbury, .	382	None.	0	None.
Prescott, . .	380	None.	0	None.
Greenwich, . .	491	None.	0	None.
Enfield, . .	1,036	Small private sewers.	200	One satinet mill, one woolen mill.
Belchertown, .	2,292	None.	0	None.
Palmer, . .	7,801	General.	3,100	One duck mill, one cotton mill, one woolen mill, one carpet mill, one wire mill.
Hubbardston, .	1,227	None.	100	One blanket mill, one beeswax refinery.
Rutland, . .	1,334	None.	100	One satinet mill.
Barre, . . .	2,059	None.	300	One cotton mill.
New Braintree, .	500	None.	0	None.
Hardwick, . . .	3,203	Private sewers.	1,500	One woolen mill, one paper mill.

CITIES AND TOWNS, CONSIDERABLE PORTIONS OF WHICH ARE WITHIN THE WATER-SHED OF THE CHICOPEE RIVER — *Concluded.*

CITY OR TOWN.	Population in 1900.	Sewerage System.	Estimated Population discharging Sewage or Sewage Effluent into River.	Manufactories discharging Wastes into River.
Ware, . . .	8,263	General.	6,000	One paper mill, one woolen mill, two cotton mills.
Paxton, . .	459	None.	0	None.
Oakham, . .	588	None.	0	None.
Spencer, . .	7,627	General.*	6,500	Three woolen mills, one satinet mill, five wire mills.
North Brookfield,	4,587	Partial.*	1,000	None.
Brookfield, . .	3,062	None.	0	Two woolen mills.
West Brookfield, .	1,448	None.	0	One creamery.
Warren, . .	4,417	None.	1,200	One cotton mill, one woolen mill, one firearms factory.
Brimfield, . .	941	None.	0	None.
Monson, . .	3,402	None.	750	Four woolen mills, one straw factory, one shoddy mill.
Ludlow, . .	3,536	General.	2,000	One jute and hemp mill.
Chicopee, . .	19,167	General.	15,000	One foundry, one carpet mill, one paper mill, one firearms factory, one rubber factory, one machine shop, one bleachery.
Wilbraham, . .	1,595	None.	300	One paper mill.
Springfield, . .	62,059	General.	1,600	One cotton mill, one worsted mill.

* Purification works in use.

The Swift River, which is the most westerly of the three branches, drains a section of the State which is sparsely populated, and has very little direct pollution.

At Enfield there is a woolen mill and a satinet mill, employing about 190 persons, sewage from which, together with some manufacturing waste, is discharged into the stream.

At West Ware a paper mill employing 26 persons discharges sewage and wastes into the stream; and at Bondsville in the town of Palmer near the mouth of the river there is a large duck and flannel mill employing 600 persons, from which sewage is discharged into the stream, together with wastes from dyeing. At this place the river receives also the sewage from a population of about 100. The water of the Swift River is clean in appearance throughout its entire course, and its condition is nowhere objectionable.

The Ware River drains a section between the water-sheds of the Swift and Quaboag rivers. At Hubbardston, about 36 miles above its mouth, the stream receives sewage and wastes from a woolen mill, in which 40 persons are employed, together with the sewage from a small population; and at

Barre the river receives wastes and sewage from a large cotton factory where 300 persons are employed, and the sewage from several smaller factories. At Rutland a satinet mill employing 65 persons discharges sewage and wastes into Long Meadow brook, a small tributary of the Ware River.

At the village of Gilbertville in the town of Hardwick there is a large woolen mill employing 825 persons, in which about 90,000 pounds of wool are scoured each week, the wastes from which, together with the wastes from dyeing and washing, are discharged directly into the river. A paper mill employing about 140 persons also discharges large quantities of wastes into the stream, and the sewage from the operatives in both these factories, together with the sewage from 250 tenement houses, is discharged in an unpurified state into the river.

The town of Ware is about 4 miles below Gilbertville. This town had in 1900 a population of 8,263, and is provided with a complete sewerage system, practically all of the sewage being discharged into the Ware River just below the thickly settled portion of the village. The shore and bed of the river in the immediate vicinity of the main outlet is in a very objectionable condition, but there is no population near the outlet or near the stream for a long distance below. A small quantity of sewage is discharged from an outlet on the opposite side of the river, but the conditions about this outlet are not objectionable. In addition to the sewage discharged into the stream from the sewers, sewage and wastes from a cotton mill employing 1,900 persons, a cotton and woolen mill employing 250 persons and a woolen mill employing 325 persons are discharged directly into the river. At the cotton and woolen mill about 8,000 pounds of wool are scoured each week.

Below Ware the river flows through the village of Thorndike in Palmer, where it receives sewage and wastes from two cotton mills employing about 600 persons, and the sewage from a few houses.

The water of the Ware River above Gilbertville is not noticeably polluted. Immediately below Gilbertville the water is objectionable in appearance, on account of the large quantity of sewage and wastes which enter it at that place; and at Ware, in the vicinity of the mills and immediately below the sewer outlet, it is very decidedly polluted at times of dry weather. Below the Ware sewer outlets the water quickly loses its polluted appearance, and when it reaches its mouth the effect of the sewage pollution upon the appearance or odor of the stream is not noticeable.

The Quaboag River, the most southerly of the branches of the Chicopee, rises in the town of Spencer, and throughout its course is used largely for manufacturing purposes. There are numerous ponds and storage reservoirs which are used to equalize the flow of the stream, so that the flow is well maintained in dry weather.

The first sources of pollution of the river are in Spencer, near the head waters. A small brook tributary to the Seven Mile River, which is one of the main tributaries of the Quaboag, flows near the central section of the village of Spencer, and receives a large quantity of refuse from the factories along its course. On this stream are located three woolen mills, a yeast factory and gas works, from all of which sewage and wastes have been discharged, until recently, into the stream. A connection has recently been made with the town sewer, so that the wastes from the yeast factory are now disposed of with the sewage of the town, and thus one of the chief sources of pollution has been removed from the brook, but the brook is still very foully polluted.

The Seven Mile River below the village receives sewage and sewage effluent from the Spencer sewerage system. The town of Spencer had a population in 1900 of 7,627, and about 3,000 persons are served by a system of sewers, the sewage from which is purified upon sand filter beds. The quantity of sewage treated on these beds varies greatly at different seasons of the year, owing to the large quantity of ground and surface water which enters the sewers at times of storm or when the level of the ground water is high. The ordinary dry-weather flow of sewage is about 375,000 gallons per day. Although the filter beds are fully capable of purifying all of the sewage, unpurified sewage is at times discharged directly into the river from the main sewer. A system of sewers which serves a few houses in another section of the town also discharges directly into the river.

Just below Spencer the river is joined by a small brook, on which are located five wire factories employing together about 85 persons, the sewage from which is all discharged into the brook, together with a small quantity of acid wastes. There is also a satinet mill on the stream about a mile below Spencer, from which the sewage from 30 persons and a small quantity of wastes are discharged.

At East Brookfield there are two woolen mills employing 150 persons, from which sewage and wastes are discharged into the stream, but no wool is scoured in either of these places. The river is used at East Brookfield as an auxiliary source of water supply for the town of Brookfield, at times when there is a shortage of water in the permanent source of supply.

A creamery is located at West Brookfield, from which offensive wastes are discharged into a ditch leading to the river.

At Warren in the villages of Warren and West Warren there are four cotton mills employing over 900 persons, sewage from which, together with a small quantity of manufacturing wastes, consisting chiefly of spent dyes, is discharged into the river. There is also a woolen mill employing 300 persons, from which sewage and wastes are discharged into the stream, but no wool is scoured. Sewage from a firearms factory employing 75 persons is discharged into the stream at this place.

In the upper portion of Palmer a small shoddy mill employing 12 persons discharges sewage and wastes into the river. A short distance below this mill a branch known as Chicopee Brook enters the river from the south, on which is the village of Monson, where there are six woolen mills employing 435 persons and a straw goods factory employing 300 persons, sewage from all of which is discharged into the stream, together with a considerable amount of manufacturing wastes, consisting chiefly of spent dyes and wool-scouring liquor, making this stream objectionable at times in appearance and odor.

Below its junction with Chicopee Brook in Palmer the river receives dye wastes and the sewage from a woolen mill employing 45 persons, also sewage and acid wastes from a wire factory employing 100 persons.

The river also receives at Palmer a small quantity of sewage from the town sewers. The population of Palmer in 1900 was 7,801. A small section of the village is provided with sewers, which receive both sewage and storm water and discharge into the river at two points. The upper outlet is into an open ditch, through which the sewage flows for a distance of about 350 feet to the river, entering the river near a highway bridge. The open ditch begins near several buildings and runs along the edge of a highway, and at times when the flow of sewage has been obstructed the ditch has been the cause of serious complaint. The sewer is now being extended to the river. The river below the outlet is not noticeably affected by the discharge of sewage into it at this point. The lower outlet is just below the Boston & Albany Railway bridge, and is at a considerable distance from any population. This outlet is unobjectionable, and the sewage in the river is noticeable for only a short distance below.

The Quaboag River is not polluted to such an extent as to be objectionable in appearance or odor, except in the immediate vicinity of the sources of pollution, in any portion of its course.

Immediately below the junction of the Ware, Swift and Quaboag rivers, at the village of Three Rivers, there is a cotton factory employing 775 persons, from which all of the sewage and a small quantity of dye wastes are discharged into the river.

The next source of pollution of the Chicopee River is at Wilbraham, where wastes and sewage from a writing-paper factory employing 250 persons are discharged into the river.

At Ludlow the sewage from a factory employing 1,750 persons is discharged into the river, but very little manufacturing waste enters the stream at this point. The village of Ludlow is provided with a system of sewers having five outlets into the river. The total population connected with the sewers discharging into the river is about 2,000, and the outlets are so located and constructed that they are not offensive.

At Indian Orchard in the city of Springfield, about a mile below Ludlow, there are eight factories employing nearly 700 persons, sewage from all of which is discharged directly into the river, together with a small amount of manufacturing waste consisting chiefly of spent dyes. At this place the river receives the sewage from a combined system of sewers serving about 1,500 persons in the village of Indian Orchard. The sewers all discharge through one main outlet located below the village, and at the time it was examined the outlet was not offensive, although sewage was observable in the river for some distance below.

In Chicopee the river receives the sewage of the principal portions of the city, together with manufacturing wastes from a large number of factories in Chicopee and Chicopee Falls. The population of Chicopee in 1900 was 19,167. The city is very thoroughly sewered, a large proportion of the sewage entering the Chicopee River, although there are some sewers which discharge into the Connecticut River.

At Chicopee Falls, the upper village, there are two principal outlets, the upper of which is into a mill pond a short distance above a dam. This outlet was formerly located immediately below the dam, at a place where at times there was no flow, the water being held back by the dam above. This condition created such a nuisance that the outlet was changed to a point just above the dam, since which time there has been no trouble.

The second outlet is into the river, just below the thickly built up portion of the village. This outlet is at a considerable distance from any houses, but sewage is plainly evident along the edge of the river for a long distance below. There is one small outlet between Chicopee Falls and Chicopee which is unobjectionable.

The sewage of the lower village of Chicopee is discharged through two outlets, the upper of which is a very small one, and causes no trouble. The lower outlet, which is the principal one, is near the mouth of the river where there is ordinarily very little current, and at times the water of the river for a considerable distance is affected by sewage.

The factories in Chicopee employ about 4,500 persons, all of the sewage being discharged into the river. The principal manufacturing wastes which tend to pollute the river are wool-scouring liquor from a small woolen mill, a small amount of paper wastes and spent dyes.

The Chicopee River below the junction of its three principal tributaries is not affected to any noticeable extent by the sewage and manufacturing wastes discharged into it, except in the city of Chicopee, where the discharge of a large quantity of sewage at the main sewer outlet causes an objectionable odor in the vicinity.

Special examinations have been made of the river and its branches, the results of which are given in the tables which follow, together with the average results of analyses of samples collected at various points.

Special Examination of Ware River in the Vicinity of Ware, Aug. 18 and 19, 1902.

[Parts per 100,000.]

Source.	Day Sample.				Night Sample.			
	Free Ammonia.	Albuminoid Ammonia.	Chlorine.	Dissolved Oxygen.	Free Ammonia.	Albuminoid Ammonia.	Chlorine.	Dissolved Oxygen.
Ware River, above Ware,	.0080	.0360	.13	66.1 55.8	.0076	.0352	.11	60.3 57.5
Ware River, below Ware, but above sewer outlets,	.0072	.0400	.15	64.1 62.9	.0096	.0380	.52	54.4 59.2
Main sewer outlet,	5.3700	1.3000	9.15	-	3.7100	.5500	5.50	-
Ware River, ½ mile below sewer outlet,	.0096	.0408	.16	69.2 63.7	.0068	.0412	.16	53.5 55.0
Ware River, 1 mile below sewer outlet,	.0080	.0424	.16	66.0 68.7	.0012	.0440	.16	56.9 49.4
Ware River, 1½ miles below sewer outlet,	.0064	.0388	.16	63.1 66.8	.0020	.0436	.16	53.4 49.1
Ware River, 2 miles below sewer outlet,	.0084	.0364	.16	-	-	-	-	-
Ware River, 3 miles below sewer outlet,	.0084	.0316	.16	62.4 64.9	.0036	.0384	.15	56.2 53.8
Ware River, 5 miles below sewer outlet, and 2½ miles above the dam at Thorndike.	.0056	.0356	.15	59.2 63.7	.0076	.0392	.15	55.8 48.2

Flow of sewage from main sewer, Ware,	157,000 gallons per day.
Flow of river at Ware,	154 cubic feet per second.

Special Examination of Quaboag River, at Palmer, Aug. 7 and 8, 1902.

[Parts per 100,000.]

Source.	Day Sample.			Night Sample.		
	Free Ammonia.	Albuminoid Ammonia.	Chlorine.	Free Ammonia.	Albuminoid Ammonia.	Chlorine.
Chicopee Brook,* near mouth,	.0420	.0260	.26	.0428	.0280	.26
Quaboag River, above junction with Chicopee Brook,*	.0028	.0202	.27	.0080	.0232	.26
Quaboag River, above lower sewer outlet, Palmer,	.0102	.0200	.29	.0156	.0288	.32
Lower sewer outlet, Palmer,	3.2300	.5000	4.95	1.4700	.2300	2.30
Quaboag River, ¾ mile below sewer outlet, Palmer,	.0104	.0228	.30	.0080	.0264	.28
Quaboag River, 1½ miles below sewer outlet,	.0088	.0200	.29	.0112	.0252	.28
Quaboag River, at mouth,	.0112	.0272	.26	.0112	.0292	.28

Flow of sewage from upper sewer, Palmer,	14,000 gallons per day.
Flow of sewage from lower sewer, Palmer,	7,000 gallons per day.
Flow of river at Palmer,	113 cubic feet per second.

Special Examination of Chicopee River, Aug. 20 and 21, 1902.

Chicopee River, above Ludlow,	.0076	.0288	.20	.0052	.0288	.19
Chicopee River, below Ludlow,	.0072	.0280	.20	.0056	.0376	.19
Chicopee River, below Indian Orchard,	.0092	.0316	.19	.0068	.0300	.19
Chicopee River, above Chicopee Falls,	.0080	.0292	.18	.0092	.0244	.19
Main sewer, at Chicopee Falls,	-	-	-	.9600	.2300	2.00
Chicopee River, below Chicopee Falls,	.0072	.0332	.20	.0064	.0300	.19
Chicopee River, below Chicopee, but above main sewer outlet,	.0074	.0300	.19	.0051	.0268	.19

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* Also known as Quaboag Brook.

CHEMICAL EXAMINATION OF WATER FROM THE CHICOPEE RIVER AND ITS TRIBUTARIES.— AVERAGES FOR SIX MONTHS, FROM JUNE TO NOVEMBER, INCLUSIVE.

Ware River, at Barre.

[Parts per 100,000.]

YEAR.	Color.	RESIDUE ON EVAPORATION.		AMMONIA.				Chlorine.	NITROGEN AS		Oxygen Consumed.	Hardness.
		Total.	Loss on Ignition.	Free.	ALBUMINOID.				Nitrates.	Nitrites.		
					Total.	Dissolved.	Sus-pended.					
1894,	.74	3.42	1.39	.0005	.0197	.0171	.0026	.12	.0008	.0000	.55	.8
1895,	.86	3.87	1.72	.0010	.0225	.0209	.0016	.15	.0033	.0001	.84	.9
1896,	.77	3.65	1.67	.0004	.0205	.0187	.0018	.12	.0027	.0000	.75	1.1
1897,	.94	3.67	1.75	.0012	.0225	.0196	.0029	.12	.0008	.0000	.88	.7
1898,	.89	3.97	2.03	.0013	.0252	.0227	.0025	.13	.0013	.0000	.95	.7
1899,	.54	3.81	1.64	.0009	.0216	.0196	.0020	.16	.0022	.0000	.67	.5
1900,	.39	4.72	1.51	.0047	.0244	.0200	.0044	.28	.0048	.0002	.52	1.2

Ware River, at Gilbertville.

1901,	.60	4.19	1.95	.0048	.0244	.0199	.0045	.17	.0025	.0001	.74	1.2
1902,	.72	4.20	1.82	.0051	.0234	.0197	.0037	.18	.0008	.0001	.89	1.0

Ware River, below Ware.

1898,	.64	4.42	1.94	.0028	.0332	.0250	.0082	.19	.0025	.0003	.77	1.0
1899,	.46	4.82	1.77	.0052	.0371	.0268	.0103	.25	.0015	.0004	.66	.9
1900,	.51	4.93	1.64	.0066	.0321	.0243	.0078	.25	.0030	.0003	.73	1.1
1901,	.73	4.79	2.15	.0082	.0300	.0242	.0058	.18	.0044	.0002	.84	1.3
1902,	.76	4.86	2.17	.0071	.0348	.0252	.0096	.23	.0040	.0003	.93	1.0

Seven Mile River, above Spencer.

1901,	.58	5.12	2.10	.0247	.0414	.0312	.0102	.32	.0070	.0006	.59	1.5
1902,	.69	5.10	1.83	.0473	.0529	.0395	.0134	.29	.0060	.0008	.66	1.5

Seven Mile River, below Spencer.

1901,	.51	8.67	3.13	.0931	.0369	.0293	.0076	1.38	.0733	.0018	.54	2.1
1902,	.21	11.88	4.70	.0158	.0228	.0170	.0058	1.76	.4467	.0035	.42	2.6

Quaboag River, above Palmer.

1899,	.38	4.44	1.75	.0018	.0234	.0205	.0029	.24	.0054	.0001	.49	1.2
1900,	.43	4.40	1.41	.0037	.0221	.0184	.0037	.26	.0040	.0001	.49	1.3
1902,	.39	4.23	1.52	.0027	.0217	.0179	.0038	.28	.0072	.0002	.51	1.2

Quaboag River, below Palmer.

1899,	.35	4.54	1.68	.0048	.0252	.0208	.0044	.26	.0060	.0002	.44	1.1
1900,	.40	4.56	1.58	.0038	.0218	.0176	.0042	.26	.0062	.0001	.48	1.2
1901,	.42	4.32	1.74	.0043	.0255	.0202	.0053	.23	.0052	.0002	.53	1.1
1902,	.41	4.55	1.64	.0077	.0242	.0196	.0046	.33	.0085	.0002	.53	1.2

CHEMICAL EXAMINATION OF WATER FROM THE CHICOPEE RIVER AND ITS TRIBUTARIES. — AVERAGES FOR SIX MONTHS, FROM JUNE TO NOVEMBER, INCLUSIVE — *Concluded.*

Chicopee River, below Ludlow.

[Parts per 100,000.]

YEAR.	Color.	RESIDUE ON EVAPORATION.		AMMONIA.				Chlorine.	NITROGEN AS		Oxygen Consumed.	Hardness.
		Total.	Loss on Ignition.	Free.	ALBUMINOID.				Nitrates.	Nitrites.		
					Total.	Dissolved.	Suspended.					
1899, ...	.39	4.62	1.65	.0047	.0255	.0221	.0034	.24	.0095	.0002	.49	1.2
1900, ...	.39	4.72	1.51	.0047	.0244	.0200	.0044	.28	.0048	.0002	.52	1.2
1901, ...	.49	4.46	1.89	.0069	.0288	.0217	.0071	.21	.0060	.0002	.61	1.2
1902, ...	.49	4.69	1.92	.0057	.0279	.0203	.0076	.28	.0118	.0001	.61	1.2

Chicopee River, at Chicopee.

YEAR.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Hardness.
1901, ...	.48	4.57	1.86	.0042	.0263	.0200	.0063	.21	.0060	.0002	.59	1.5

CONCORD RIVER.

The Concord River is formed by the Sudbury and Assabet rivers, which unite in the town of Concord. The river flows in a northerly direction, and discharges into the Merrimack River in the city of Lowell.

The following tables give statistics relative to the drainage areas and the population upon them at various points : —

LOCALITY.	Distance above Mouth (Miles).	Drainage Area (Square Miles).	Population on Drainage Area.	Population per Square Mile.	Estimated Population discharging Sewage or Sewage Effluent into River.
Sudbury River, above lowest dam of metropolitan water works.	36.0	75.2	22,400	298	0
Lake Cochituate (metropolitan water works),	–	18.9	–	–	–
Total used for metropolitan water supply, .	–	94.1	–	–	–
Sudbury River, below Saxonville,* . .	31.5	106.6	40,700	382	400
Sudbury River, at mouth,*	16.0	164.0	45,700	279	450
Assabet River, below Westborough filtration area.	42.5	8.0	500	63	3,000
Assabet River, below Hudson, . . .	32.0	73.3	10,000	137	5,200
Assabet River, below Maynard, . . .	23.0	115.6	16,800	145	6,450
Assabet River, at mouth, ...	16.0	176.8	22,200	126	7,500
Total, Sudbury and Assabet,* . . .	16.0	340.8	67,900	199	7,950
Concord River, at dam, North Billerica,* .	4.5	370.6	72,600	196	23,900
Concord River, at mouth,*	0.0	402.1	107,400†	268	43,900

* Including portion used for metropolitan water supply.

† The population from which sewage is actually discharged into the river in the city of Lowell is larger than the population within the natural water-shed of the river in the city.

Cities and Towns, Considerable Portions of which are within the Water-shed of the Concord River.

City or Town.	Population in 1900.	Sewerage System.	Estimated Population discharging Sewage or Sewage Effluent into River.	Manufactories discharging Wastes into River.
Hopkinton,	2,623	None.	0	None.
Southborough,	1,921	None.	0	None.
Marlborough,	13,609	General.*	12,000	None.
Ashland,	1,525	None.	0	None.
Framingham,	11,302	General.*	400	One woolen mill.
Natick,	9,488	General.*	0	None.
Sudbury,	1,150	None.	0	None.
Wayland,	2,303	None.	0	None.
Westborough,	5,400	General.*	3,000	None.
Shrewsbury,	1,626	None.	0	None.
Northborough,	2,164	None.	200	One woolen mill.
Berlin,	1,003	None.	0	None.
Hudson,	5,454	Partial.	2,000	One woolen mill, one tannery.
Bolton,	770	None.	0	None.
Stow,	1,002	None.	50	One woolen mill.
Maynard,	3,142	Partial *	1,200	One woolen mill.
Boxborough,	316	None.	0	None.
Acton,	2,120	None.	50	One shoddy mill.
Concord,	5,652	General.*	4,000	None.
Carlisle,	480	None.	0	None.
Billerica,	2,775	Partial.*	1,000	Two woolen mills.
Chelmsford,	3,984	None.	0	None.
Littleton,	1,179	None.	0	None.
Lowell,	94,969	General.	20,000	One woolen mill, one cotton mill, one bleachery.

* Sewage purification works in use.

The Sudbury River above Framingham is used as one of the sources of water supply of the metropolitan water district, and during dry weather a large part of the flow of the stream above this point is diverted. The area of the water-shed of the main stream above the point of diversion is about 75 square miles. Lake Cochituate, situated on a tributary which joins the main stream at Saxonville in Framingham, is also a source of water supply of the metropolitan district, and in these portions of the water-shed of the Sudbury River the streams receive no direct pollution, as practically all of the sewage and manufacturing wastes are kept out of the water and the sewage of the principal villages is removed to purification works outside of these portions of the water-shed. Below the point of diversion the river flows through the town of Framingham, receiving in the village of Saxonville the sewage and manufacturing wastes from a woolen mill employing about 350 persons, in which about 50,000 pounds of wool are scoured weekly, and large quantities of water used for washing and dyeing are discharged into the river, greatly polluting the stream. The river also receives at this place the sewage from a considerable population, although the village has no general sewerage system.

Bannister Brook, which receives the effluent from the sewage purification areas of the towns of Framingham and Natick, enters the river at Saxonville. This stream, which also receives water which may overflow or be wasted from Lake Cochituate, is sometimes seriously polluted by crude or partially purified sewage from the Natick sewage disposal area.

The town of Framingham had in 1900 a population of 11,302. That portion of the town included in the village of South Framingham, which contains probably about half of the population of the town, is provided with sewers, the sewage being collected at a pumping station and pumped to filter beds. The sewage from the Reformatory Prison for Women at Sherborn is also taken into this system. The average daily quantity of sewage pumped amounted in 1902 to about 580,000 gallons per day. All of the sewage collected in the sewerage system is treated on the filter beds, and numerous examinations have shown that the sewage is very thoroughly purified before it enters Bannister Brook, which conveys the effluent to the Sudbury River.

The town of Natick had in 1900 a population of 9,488. The town drains naturally into Lake Cochituate, one of the tributaries of the Sudbury River, which is used as a source of water supply for the metropolitan district.

The main village of Natick is very thoroughly sewered, the sewage being pumped to a filtration area adjacent to the Framingham filtration area. The average daily quantity of sewage pumped in 1902 amounted to 600,000 gallons. Although the area of land owned by the town is ample, the area which has been prepared is insufficient for the large flow of sewage at times when the flow is increased by leakage of ground water into the sewers; and the sewage passing through the filters is imperfectly purified, and at times unpurified sewage has been discharged directly into Bannister Brook.

Below Saxonville the river flows through extensive meadows having a very slight fall to its junction with the Assabet River. In this portion of its course it receives no additional pollution except from the sewage-disposal area at Marlborough, which is near the head waters of a tributary which enters the river at Wayland.

The city of Marlborough had in 1900 a population of 13,609, and is very thoroughly sewered, a large proportion of the houses being connected with the sewers. A large section of the city is within the water-shed of the Sudbury River, above the point where it is diverted for the water supply of the metropolitan district; but the filtration area is outside of this water-shed and on the water-shed of a tributary of the Sudbury River which enters it at Wayland.

The average quantity of sewage received at the filtration area during the year 1902 was 650,000 gallons per day. The filtration area is inadequate to purify the sewage at times of high flow, and at such times large quantities of unpurified sewage are discharged into the brook, and some of the sewage which is treated on the filter beds is imperfectly purified.

Above the mills at Saxonville the water of the Sudbury River is of good quality; but below the mills, where it passes through a densely populated section of the village, it is very foul and exceedingly offensive, especially at times of low flow and when no water is passing the dam. As the water passes through the extensive meadows it becomes purified and diluted to such an extent that when it has passed Wayland, about 7 miles below Saxonville, the pollution cannot be detected by observation.

The Assabet River, the other branch of the Concord, rises in Westborough, not far from the head waters of the Sudbury River. In Westborough the river receives the effluent from the sewage purification works of that town. The population of Westborough in 1900 was 5,400. A sewerage system was constructed in 1892, which serves practically the whole of the main village, a considerable portion of which naturally drains into the Sudbury River; but the sewage is conveyed to a filtration area near the Assabet River, where it is purified on sand filter beds, the effluent flowing into the river. The quantity of sewage purified amounts to about 250,000 gallons per day, and, although the purification works are not operated in such a manner as to secure the best results, the effluent does not have a visible effect upon the water of the river.

At Northborough the river receives sewage from four factories employing about 240 persons, and wool-scouring wastes and spent dyes from a factory where cashmere is made. The river also receives, through a tributary which enters it at Northborough, the sewage effluent, and at times a small quantity of unpurified sewage, from the Westborough Insane Hospital, which has a population of about 1,000.

At Hudson, the next town through which the river passes, sewage from eight factories employing about 1,275 persons is discharged directly into the river, and large quantities of wastes from a tannery and a woolen mill are discharged into the stream.

The town of Hudson had in 1900 a population of 5,454. The town has no complete system of sewerage, but there are numerous sewers or storm-water drains, which receive the sewage from the thickly built up portion of the village, and discharge directly into the river. Plans have been prepared for the construction of a system of sewerage, and for the purification of the sewage upon sand filter beds to be located near the Assabet River below the village.

At Stow, 3 miles below Hudson, there is a woolen mill employing 90 persons, in which about 12,000 pounds of wool are scoured each week, and all of the sewage and wastes are discharged directly into the stream.

At Maynard, 5.5 miles below Stow and 7.5 miles above the junction of the Assabet and Sudbury rivers, there is a large woolen mill employing about 2,300 persons. Sewage from the operatives and wastes from scouring about 70,000 pounds of wool per week, together with the wastes from the dye house and from washing cloth, are discharged directly into the stream. Besides the sewage which enters the river from the factory, there are several houses connected with small sewers which discharge into the stream. A small section of the town, containing about 100 houses which have been recently erected, is provided with a sewerage system, the sewage being pumped to sand filter beds, where it is purified. A population of about 500 is served by these sewers.

The American Powder Company, situated a short distance below Maynard, employs about 50 persons, and the sewage from some of them is discharged into the river. No manufacturing wastes are produced here.

At Concord Junction the river receives sewage from a harness factory employing about 160 persons, but no manufacturing wastes are produced. Just below the harness factory the river receives the flow of Fort Pond Brook, which flows through the village of South Acton, and at that place receives sewage from three mills employing about 40 persons, and the manufacturing wastes from a small shoddy mill.

The Massachusetts Reformatory at Concord Junction, which has a population of about 1,200, discharges sewage upon land on the edge of the river, and the effluent flows into the river. A small quantity of wool is scoured at this institution, and the wastes from the wool-scouring processes are discharged with the sewage upon land.

The Assabet River above Hudson is not a badly polluted stream, but the sewage and wastes discharged into it at Hudson make it unsightly and offensive at times. Immediately below Maynard the stream is very badly polluted by the wool-scouring wastes, which make it offensive to sight and smell, but its character improves from this place until it unites with the Sudbury River at Concord.

The Concord River between the junction of the Assabet and the Sudbury rivers and the village of North Billerica flows with a very sluggish current through extensive meadows, and in this portion of its course receives no additional pollution. The effluent from the Concord sewage purification works enters the stream a short distance below Concord.

The town of Concord had in 1900 a population of 5,652. A sewerage system was constructed in 1900, the sewage being pumped to a filtration area below the town. The average quantity of sewage pumped in 1902 was 312,000 gallons per day. All of the sewage conveyed to this area appears to be thoroughly purified.

At North Billerica, 10.5 miles below Concord, the river receives the effluent from the sewage purification works of that village. A sewerage system was constructed in 1902, by which the sewage is conveyed to an area near the river below the village, where it is discharged on sand filter beds. At this village there are two woolen mills employing about 450 persons, the sewage from which is discharged directly into the stream. At one of these mills large quantities of wool-scouring wastes, together with dye-house wastes, are discharged into the river. At the other mill no wool is scoured, and the only wastes are those from the dye house.

Below North Billerica the river flows through a portion of the city of Lowell, and discharges into the Merrimack River.

In Lowell the Concord River receives a large quantity of sewage and manufacturing wastes from two tanneries, two large woolen mills and various smaller factories. Two large and several small sewers also discharge into the river near its mouth. There are numerous dams and mill ponds on the stream in Lowell, and the water has an objectionable appearance near its mouth at times of low flow.

Special examinations have been made of the Concord River and of each of its two branches, the results of which, together with the average results of analyses of samples collected during the drier months for several years, are given in the following tables: —

SPECIAL EXAMINATION OF SUDBURY RIVER, FEB. 27, 1901.

[Parts per 100,000.]

SOURCE.	Free Ammonia.	Albuminoid Ammonia.	Chlorine.
Below Saxonville, ...	.5040	.2720	1.11
At Stone bridge, 2.7 miles below Saxonville, ...	.0940	.0940	1.68
At Farm bridge, 6 miles below Saxonville, ...	.0172	.0206	.68
At Canal bridge, Wayland, ...	.0244	.0214	.65
At Heath’s bridge, Concord, ...	.0142	.0250	.62
Near mouth, Concord, ...	.0144	.0284	.59

SPECIAL EXAMINATION OF ASSABET RIVER, SEPT. 9, 1902.

Assabet River, just below sewage purification works, Westborough,	.0444	.0304	.96
Assabet River, at Milk Street, Westborough, ...	.0024	.0204	.60
Assabet River, at Main Street, Northborough, ...	.0160	.0220	.52
Cold Harbor Brook, at mouth, Northborough, ...	.0140	.0148	.27
Assabet River, 2 miles below Northborough, ...	.0034	.0540	.46
Assabet River, ½ mile above Washington Street, Hudson, ...	.0060	.0396	.42
Clye Brook, at Cottage Street, Hudson, ...	.0550	.0750	.47
Clye Brook, at mouth, Hudson, ...	.0764	.0336	.58
Bruce’s mill pond, at outlet, Hudson, ...	.0024	.0332	.41
Assabet River, 1½ miles below Washington Street, Hudson, . . .	.1260	.0900	1.76

SPECIAL EXAMINATION OF ASSABET RIVER, SEPT. 9, 1902 — *Concluded.*

[Parts per 100,000.]

SOURCE.	Free Ammonia.	Albuminoid Ammonia.	Chlorine.
Assabet River, 100 feet above entrance of Assabet Brook, Stow,	.0032	.0296	.65
Assabet River, below Stow,	.0044	.0156	.37
Assabet River, ½ mile below Summer Street, Maynard,	.0110	.0760	.58
Assabet River, 500 feet above Main Street, Concord,	.0260	.0636	.66
Assabet River, 100 feet above entrance of Fort Pond Brook, Concord,	.0040	.0256	.32
Fort Pond Brook, at mouth, Concord,	.0340	.0440	.68
Assabet River, at mouth, Concord,	.0272	.0412	.64

CHEMICAL EXAMINATION OF WATER FROM THE CONCORD RIVER AND ITS TRIBUTARIES.— AVERAGES FOR SIX MONTHS, FROM JUNE TO NOVEMBER, INCLUSIVE.

Sudbury River, below Saxonville.

[Parts per 100,000.]

YEAR.	Color.	RESIDUE ON EVAPORATION.		AMMONIA.				Chlorine.	NITROGEN AS		Oxygen Consumed.	Hardness.
		Total.	Loss on Ignition.	Free.	ALBUMINOID.				Nitrates.	Nitrites.		
					Total.	Dissolved.	Sus-pended.					
1901,	.84	7.22	3.37	.0073	.0624	.0431	.0193	.38	.0050	.0005	1.05	1.9
1902,	.38	6.39	2.57	.0150	.0424	.0272	.0152	.60	.0103	.0005	.55	2.2

Sudbury River, at Mouth.

1901,	.60	5.77	2.47	.0054	.0311	.0283	.0028	.44	.0047	.0001	.75	1.9
1902,	.52	6.10	2.25	.0049	.0278	.0251	.0027	.52	.0042	.0002	.64	1.9

Assabet River, at Westborough.

1898,	.99	5.59	2.84	.0024	.0348	.0324	.0024	.31	.0012	.0000	1.18	1.5
1899,	.63	6.43	2.37	.0093	.0364	.0332	.0032	.49	.0037	.0001	.90	1.8
1900,	.63	6.41	2.29	.0083	.0366	.0331	.0035	.66	.0060	.0001	.86	1.7
1901,	.87	5.33	2.72	.0032	.0337	.0308	.0029	.35	.0025	.0000	1.11	1.6
1902,	.72	5.62	2.26	.0030	.0228	.0254	.0034	.45	.0015	.0001	.91	1.8

CHEMICAL EXAMINATION OF WATER FROM THE CONCORD RIVER AND ITS TRIBUTARIES. — AVERAGES FOR SIX MONTHS, FROM JUNE TO NOVEMBER, INCLUSIVE — *Concluded.*

Assabet River, below Hudson.

[Parts per 100,000.]

Year.	Color.	Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
					Albuminoid.							
		Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Sus-pended.		Nitrates.	Nitrites.		
1898, ...	.79	5.61	2.38	.0062	.0335	.0291	.0044	.39	.0063	.0003	.87	1.6
1899, ...	.50	8.30	3.01	.0205	.0457	.0383	.0074	.80	.0020	.0004	.73	2.1
1900, ...	.48	8.05	2.05	.0382	.0501	.0362	.0139	1.27	.0028	.0007	.72	2.0
1901, ...	.66	5.47	2.38	.0193	.0375	.0295	.0080	.79	.0107	.0005	.91	1.8
1902, ...	.64	7.06	2.69	.0189	.0464	.0330	.0134	.84	.0077	.0005	.74	1.9

Assabet River, below Maynard.

Year.	Color.	Residue Total.	Loss on Ignition.	Ammonia Free.	Albuminoid Total.	Dissolved.	Sus-pended.	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Hardness.
1898, ...	.77	5.93	2.59	.0020	.0387	.0301	.0086	.43	.0030	.0003	.89	1.5
1899, ...	.51	6.70	2.21	.0185	.0414	.0327	.0087	.73	.0043	.0003	.62	1.7
1900, ...	.50	5.72	1.73	.0217	.0386	.0304	.0082	.70	.0031	.0002	.59	1.4
1901, ...	.73	6.57	2.67	.0211	.0428	.0351	.0077	.45	.0052	.0002	.90	1.6
1902, ...	.69	7.27	2.87	.0099	.0592	.0381	.0211	.57	.0033	.0002	.83	1.6

Assabet River, at Mouth.

Year.	Color.	Residue Total.	Loss on Ignition.	Ammonia Free.	Albuminoid Total.	Dissolved.	Sus-pended.	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Hardness.
1901, ...	.78	6.60	2.82	.0177	.0416	.0369	.0047	.49	.0068	.0005	.90	1.7
1902, ...	.80	6.16	2.28	.0170	.0355	.0313	.0042	.48	.0080	.0007	.84	1.4

Concord River, at Billerica.

Year.	Color.	Residue Total.	Loss on Ignition.	Ammonia Free.	Albuminoid Total.	Dissolved.	Sus-pended.	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Hardness.
1902, ...	.68	5.98	2.18	.0091	.0347	.0272	.0075	.53	.0052	.0004	.78	1.7

CONNECTICUT RIVER.

The Connecticut River, the largest stream in Massachusetts, rises in the extreme northerly portion of New Hampshire, and flows in a southerly direction, forming the boundary between New Hampshire and Vermont to the Massachusetts line, thence across the States of Massachusetts and Connecticut, emptying into Long Island Sound. The water-shed of the portion of the stream above Massachusetts is steep, and the river has a rapid fall and is subject to considerable variations in flow.

In Massachusetts that portion of the water-shed west of the river has steep slopes, but the water-shed east of the river is very much flatter and contains large storage reservoirs, so that the flow of the streams which are tributary from that side is much larger in dry weather in proportion to the size of their water-shed than the flow from the west side. The river has comparatively little fall in Massachusetts, the only falls which are utilized being those at Turner's Falls and at Holyoke. The four principal tributaries, the Deerfield, Miller's, Westfield and Chicopee rivers, are treated separately in this report, and the description of each of these streams will be found under the name of the stream.

The following tables give statistics in regard to drainage areas and the population on them at various points: —

LOCALITY.	Distance above Connecticut Line (Miles).	Drainage Area (Square Miles).	Population on Drainage Area.	Population per Square Mile.	Estimated Population discharging Sewage or Sewage Effluent into River in Massachusetts.
Above Miller's River,	55.7	7,062.7	192,200	27.0	2,500
Below Miller's River,	55.7	7,452.7	215,600	29.0	23,300
Below Deerfield River,	49.3	8,164.6	242,900	30.0	31,000
Above Mill River,	22.7	8,394.3	260,600	31.0	32,500
Below Manhan River,	22.4	8,539.0	286,600	34.0	56,000
At Holyoke dam,	15.8	8,606.6	293,600	34.0	61,000
Above Chicopee River,	9.6	8,626.6	340,000	39.0	99,000
Below Chicopee River,	9.6	9,357.0	417,700	45.0	138,000
Above Westfield River,	4.0	9,404.1	484,100	51.0	201,000
Below Westfield River,	4.0	9,922.5	511,200	52.0	213,500
Above State line,	0.0	9,953.0	513,000	52.0	215,000

PRINCIPAL CITIES AND TOWNS ON THE CONNECTICUT RIVER AND ITS TRIBUTARIES.

CITY OR TOWN.	Population in 1900.	Stream on which Located.	Distance above Massachusetts and Connecticut State Line (Miles).	Sewerage System.
St. Johnsbury, Vt.,	7,010	Moose.	204.2	General.
Littleton, N. H.,	4,066	Ammonoosuc.	205.0	General.
Haverhill, N. H.,	3,414	Connecticut.	178.0	-
Lebanon, N. H.,	4,965	Connecticut.	146.3	-
Randolph, Vt.,	3,141	White.	166.7	-
Hartford, Vt.,	3,817	Connecticut.	138.9	-
Newport, N. H.,	3,126	Sugar.	141.5	General.

PRINCIPAL CITIES AND TOWNS ON THE CONNECTICUT RIVER AND ITS TRIBUTARIES — *Concluded.*

CITY OR TOWN.	Population in 1900.	Stream on which Located.	Distance above Massachusetts and Connecticut State Line (Miles).	Sewerage System.
Claremont, N. H.,	6,498	Sugar.	129.7	None.
Springfield, Vt.,	3,432	Black.	115.7	-
Rockingham, Vt.,	5,809	Connecticut.	103.4	-
Brattleborough, Vt.,	6,640	Connecticut.	77.6	General.
Keene, N. H.,	9,165	Ashuelot.	91.4	General.
Gardner,	10,813	Miller's.	96.7	General.*
Winchendon,	5,001	Miller's.	92.1	Partial.
Athol,	7,061	Miller's.	75.5	General.
Orange,	5,520	Miller's.	69.5	General.
Deerfield,	1,969	Deerfield.	53.2	None.
Greenfield,	7,927	Deerfield.	52.0	General.
Montague,	6,150	Connecticut.	46.0	Partial.
Amherst,	5,028	Connecticut.	32.0	General.*
Northampton,	18,643	Mill.	24.5	General.
Easthampton,	5,603	Manhan.	25.5	General.
South Hadley,	4,526	Connecticut.	15.9	Partial.
Holyoke,	45,712	Connecticut.	15.9	General.
Spencer,	7,627	Chicopee.	55.3	General.*
Brookfield,	3,062	Chicopee.	48.8	None.
North Brookfield,	4,587	Chicopee.	50.8	Partial.*
Warren,	4,417	Chicopee.	42.4	None.
Monson,	3,402	Chicopee.	34.5	None.
Palmer,	7,801	Chicopee.	30.5	General.
Hardwick,	3,203	Chicopee.	46.0	Private sewers.
Ware,	8,263	Chicopee.	38.6	General.
Ludlow,	3,536	Chicopee.	18.5	General.
Chicopee,	19,167	Chicopee.	10.6	General.
West Springfield,	7,105	Connecticut.	6.0	General.
Springfield,	62,059	Connecticut.	5.7	General.
Westfield,	12,310	Westfield.	16.0	General.

* Sewage purification works in use.

Above the point where it enters Massachusetts the river receives comparatively little sewage, but there are numerous factories on the stream and its tributaries from which sewage and manufacturing wastes are discharged. The water, however, gives very little indication of sewage pollution where the stream enters Massachusetts.

About 10 miles below the New Hampshire line the river is joined by Miller's River, which enters it from the east, about four miles above Turner's Falls. The water of this river is somewhat more polluted than that of the Connecticut River, although the pollution is not noticeable at its mouth.

At Turner's Falls there is a large number of mills employing together about 1,600 persons, the sewage and manufacturing wastes from which are all discharged into the Connecticut River. The principal wastes which tend to pollute the water are those from three large paper mills. The sewage from the village of Turner's Falls is also discharged into the Connecticut River through an outlet situated on the edge of the stream at some distance below the village. The outlet is above the low-water level of the river, and might be objectionable at times, but there are no dwelling houses within a considerable distance of it.

About 3 miles below Turner's Falls the river receives the flow from the Deerfield River, on the west. This river receives very little pollution except that from Greenfield, which enters it near its mouth.

Below the Deerfield there are no important sources of pollution as far as Fort River, which enters the Connecticut from the east, opposite the city of Northampton. In this portion of its course the river receives storm water and a very small amount of sewage at various places from the small villages of Sunderland, South Deerfield and Hatfield; but the quantity of sewage discharged is so small in comparison to the flow of the stream that its effect on the river is not noticeable except by analysis.

The town of Amherst, which had in 1900 a population of 5,028, is situated on Fort River, about 7 miles from its mouth. The town is provided with a general sewerage system, which discharges at two outlets, the principal one being into the head waters of Fort River. The sewage which is discharged at this outlet is first passed through settling tanks, which remove a small portion of the solid matter. At the other outlet the sewage is discharged on land, where it collects in pools from which it finds its way more or less directly into a tributary of Fort River.

Mill River, one of the smaller tributaries of the Connecticut, rises in the town of Williamsburg and flows through the city of Northampton, entering the Connecticut River just below that city, and about 7 miles above Holyoke. The river has a rapid fall, and much of this fall is utilized for manufacturing purposes. It has a water-shed of 55 square miles at its mouth.

In the village of Williamsburg there are numerous private sewers, through which practically all of the sewage of the buildings which are situated near the river is discharged. There are also three small factories employing about 20 persons, sewage from which is discharged into the stream, but no wastes are produced at these factories.

In the village of Haydenville in Williamsburg, about two miles below the village of Williamsburg, there are two factories employing about 350 persons, which discharge sewage into the river, and from one of them, a silk mill, a small quantity of polluted wastes is discharged into the stream.

At the village of Leeds in the city of Northampton there are four factories employing 260 persons, discharging sewage into the river, and a small quantity of waste is discharged from a large silk mill.

At Bay State, 2 miles below Leeds, the river receives sewage from about 850 persons employed in three factories, two of which are large silk factories, from which considerable quantities of wastes are discharged, and from the third foul wastes from treating bones and bristles are discharged into the stream.

In Northampton proper there are three factories employing about 480 persons, which discharge sewage into the river, but very little manufacturing wastes are produced in these factories.

The city of Northampton had in 1900 a population of 18,643. The city is provided with a sewerage system, which is built in part on the combined plan, the sewage all being discharged into Mill River. There are two principal outlets, the larger one on the easterly side of the river below the last dam and below the thickly settled portion of the city, and a smaller outlet directly opposite the first. Besides these outlets there are several storm-water overflows at convenient points into the river, and there are several small sewers which discharge sewage from a few houses into the river at various places along its course through the city.

The river has a small water-shed in comparison to the sewage discharged into it, and during much of the time the water is held back by the numerous dams, so that the sewage forms a large proportion of the flow of the stream below the sewer outlets. There is but a small population near the sewer outlets and in the vicinity of Mill River below the outlets.

The river flows for a distance of about a mile from the sewer outlets to the Connecticut River, and throughout this entire distance the water is very foully polluted. Plans have been made for extending the main sewer to a point in the Connecticut River a short distance above the mouth of Mill River.

The discharge of large quantities of storm water through the storm water overflows mingled with sewage, as at present, is objectionable on account of the numerous mill ponds in the thickly built up section of the city, the level of the water in which fluctuates considerably, leaving large areas of the bottom exposed at times.

Just below Mill River enormous quantities of wastes from sulphite pulp works are discharged into the river. These wastes carry with them a large amount of pulp, which is deposited in the bed of the river in front of the outlet, and at times of low water these deposits are exceedingly offensive. The wastes mingle with the polluted waters of Mill River along the westerly side of the Connecticut, and the odor is very offensive for 1,000 feet or more.

Special examinations of Mill River and of the Connecticut River immediately below Mill River have been made, the results of which are given in the tables on pages 377 and 378.

A short distance below the outlet of the sewer from the sulphite pulp works the Connecticut River is joined by the Manhan River, one of the small tributaries from the west, draining an area between the water-sheds of the Westfield and Mill rivers.

The water of the upper portion of the Manhan River is used for the water supply of the city of Holyoke, and during times of low flow in the river all of the water from this portion of the water-shed is diverted from the river.

The following table gives data in relation to the drainage areas and the population on the drainage areas at various points: —

LOCALITY.	Distance above Mouth (Miles).	Drainage Area (Square Miles).	Population on Drainage Area.	Population per Square Mile.	Estimated Population discharging Sewage into River.
Manhan River, at dam of Holyoke water works.	14.3	13.2	200	15	0
Manhan River, just above Broad Brook, .	2.0	71.0	3,000	42	1,000
Broad Brook, at mouth, ...	2.0	12.4	4,500	363	3,000
Manhan River, at mouth, ...	0.0	89.4	8,100	91	4,000

The only town from which the Manhan River receives any pollution is Easthampton, much of the thickly settled portion of which is on the watershed of Broad Brook, the principal tributary of the river.

The town of Easthampton had in 1900 a population of 5,603. The town is quite thoroughly sewered by a system of separate sewers discharging at five principal outlets. A large proportion of the population is served by sewers discharging through two outlets near the upper end of a mill pond on Broad Brook. This mill pond is about three-quarters of a mile long and has an area of approximately 44 acres. The principal outlet discharges just below the surface of the water and there is a deposit of organic matter in its vicinity which is very objectionable. The wastes from a gas factory are discharged into the pond just below this outlet. The pond also receives sewage and manufacturing wastes from several factories, the principal one being a rubber factory employing 300 persons. Sewage has been discharged into the pond for a period of about eight years, but during two years of this time the pond has been drawn off, so that the sewage was discharged into a flowing stream. There is considerable population all about the pond, and there is a large mill at its outlet.

The water of the mill pond on Broad Brook is badly polluted, — sufficiently so to be objectionable for use for manufacturing purposes by the mills situated near the outlet of the pond, but is not offensive in odor or noticeably objectionable in appearance.

The Manhan River above the point where it is joined by Broad Brook receives sewage from a small population, discharged at two outlets, which are located at a considerable distance from any population, and which appear to be unobjectionable.

Below Broad Brook the river flows for about a mile through an uninhabited region to the Ox Bow on the Connecticut River, into which it discharges. The Ox Bow was formerly the channel of the Connecticut River, but a new channel was formed and one end of the Ox Bow was filled in, so that there is no flow through it, and it is now a stagnant arm of the Connecticut River. The height of water fluctuates with the height in the Connecticut River, and at times when the water of the river is rising the water flows from the river into the Ox Bow. A large pulp mill and a saw mill are situated on the island formed by the Ox Bow; and the Ox Bow is used for the storage of logs, the entire surface of the water being at times covered with logs, and much bark and waste material are thrown into the water.

A special examination of Broad Brook and the Manhan River was made on July 14 and 15, 1902, the results of which are given in the table on page 377.

The effect of the discharge of the highly polluted water of Mill River, the wastes from the pulp mill and the Manhan River is not noticeable in the Connecticut River a short distance below the sources of pollution on the west side of the stream, as stated above.

The Holyoke dam is about 6.5 miles below the mouth of the Manhan River. The city of Holyoke is situated on the westerly side and the village of South Hadley Falls on the easterly side of the river at this point, and from both of these places sewage and manufacturing wastes are discharged into the river.

The sewers of Holyoke are built on the combined plan, the system of carrying the sewage and storm water in the same pipes having grown up gradually, as in many other cities in the State, until it includes nearly all of the area of the city. The separate system is being introduced for the higher areas and new sections of the city located at a considerable distance back from the river, and in future extensions of the sewers it is probable that the separate system will be employed.

The sewage of the city of Holyoke is discharged into the Connecticut River at eight different outlets, and there are two storm overflows into the canals.

The principal sewer outlet for the northerly portion of the city, known as the Walnut Street outlet, is located above the Holyoke dam. At this outlet a large quantity of sewage is discharged at a point where the flow of the river is very sluggish on account of the effect of the dam, and the sewage remains in the neighborhood of the outlet, where there are considerable deposits of sewage. The conditions about this outlet are very foul. The outlet is also objectionable because the sewage from this outlet finds its way into the canals, the water of which is used in the mills for many purposes, and may be used for drinking. A plan for diverting the sewage from this outlet to an outlet below the city has been prepared, but the work has not yet been done.

The main outlet for the main and southerly portions of Holyoke is located at the southerly end of the city, and discharges through a stone pier at the edge of the river. This outlet was evidently at one time carried out a considerable distance into the river; but the pipe is now broken, and sewage discharging at the edge of the river collects in a large pool in the neighborhood, and the odor about this outlet is very offensive. There are no dwelling houses within a considerable distance.

A short distance above this outlet at the foot of Berkshire Street is an outlet from the Elmwood district, discharging at the edge of the river. There is a large area of flats about this outlet, upon which sewage collects and gives off an offensive odor. This outlet is located at a considerable distance from any dwelling house.

In the region between the upper outlet at Walnut Street and Elmwood Street, sewers for the area of the city lying between the canals and the river have been provided, which discharge at four main outlets. The outlets at Mosier and Appleton streets discharge near the edge of the river, the former at a place used as a dump, and both of these outlets are located at a considerable distance from any dwelling house. While sewage collects about these outlets to some extent, they were not seriously objectionable at the time they were examined.

There is a similar outlet at Jackson Street, where the sewage collects in the neighborhood and causes a disagreeable odor.

The remaining outlet, located at Sargent and Hamilton streets, discharges through a wall in the middle of a canal wasteway, and when the water is wasting from the canal very little odor is noticeable in the neighborhood of this outlet; when no water is wasting, the sewage collects in a large pool about the outlet in the immediate neighborhood of mills in which many operatives are employed, creating a very objectionable nuisance.

In addition to the sewage discharged into the river from the city sewers, the river receives much sewage, discharged into it or into the canals, from the various factories in Holyoke, and enormous quantities of wastes.

The factories of various kinds from which considerable quantities of sewage are discharged into the river are classified in the following table: —

KIND OF FACTORY.	Number of Factories.	Number of Persons employed.	KIND OF FACTORY.	Number of Factories.	Number of Persons employed.
Paper, . . .	19	4,230	Cotton thread, . .	1	1,650
Woolen, . . .	6	2,310	Silk, ...	1	1,000
Dye works, . .	1	75	Cotton, . . .	2	1,430
Metal works, . .	3	215	Machinery, . .	2	215

The principal manufacturing wastes which tend to pollute the river are the wastes from the large paper mills, and the effect of the discharge of these wastes is observable in the river for a considerable distance below the city.

The town of South Hadley is located on the easterly side of the river, opposite the city of Holyoke. This town had in 1900 a population of 4,526. The principal village in the town is South Hadley Falls, which is located on the bank of the river near the Holyoke dam. The village is provided with a system of sewers built to receive storm water as well as sewage, the first sewer having been constructed in 1885. The sewage at present discharges at three main outlets.

The first of these outlets discharges into the river above the Holyoke dam, about opposite the junction of Taylor and Canal streets. The sewer ends in low ground about 100 feet from the river, and the sewage collects in a large pool, having an area of about 500 square feet at the time the examination was made, which was filled with weeds, grasses and rubbish of various sorts. The odor from this stagnant pool of sewage was extremely offensive, and there were several houses not far from it.

The next sewer down stream discharges into the tail-race below the mills opposite Bardwell Street. The sewage is noticeable in the stream for a considerable distance below the outlet, but the odor is not very noticeable in the neighborhood when the mills are running. This outlet would be objectionable at times when the flow through the tail-race was small.

The sewage of the southerly portion of the village discharges through a main outlet into the Connecticut River a few feet below the Holyoke bridge. Sewage from this outlet spreads over a considerable area, but under ordinary conditions there is a considerable flow of water past the outlet, so that the conditions are not objectionable.

In the village of South Hadley Falls there are two large paper mills employing about 225 persons, sewage and wastes from which are discharged directly into the river.

The sewage of the village of Willimansett in Chicopee discharges into the

Connecticut River opposite Holyoke, but the conditions about the sewer outlets have not been found to be objectionable.

The next source of pollution below Holyoke is the city of Chicopee, which is situated about 6.2 miles below the Holyoke dam. The Chicopee River flows through this city, and receives practically all of the sewage and wastes from it. The condition of the Chicopee River has already been described.

Just below Chicopee are the city of Springfield and the town of West Springfield.

The city of Springfield is situated on the east bank of the Connecticut River, 5.5 miles above the point where the river crosses the southern boundary of Massachusetts into Connecticut. Its population in 1900 was 62,059.

The first sewers in the city were built many years ago, and about thirty years ago a general system of combined sewers was designed for the thickly settled portions of the city, which has been extended from time to time as became necessary. The further extension of the combined system of sewers in the higher portions of the city remote from the river is found to involve much expense, and the separate system is being employed in this portion of the city, and will be employed in developing the sewerage of the Mill River valley in the southerly part of the city.

The sewage of the principal portion of the city of Springfield is discharged directly into the Connecticut River, without treatment, at twelve outlets. The height of water in the Connecticut River opposite Springfield is affected somewhat by the dam at Enfield, Conn., but there is generally a good current in the stream opposite the city. The freshets in the spring raise the height of the water in the river in extreme cases to a level 20 feet above the ordinary summer stage of the stream. There are four outlets into the Mill River, a tributary of the Connecticut River, in the southerly part of the city; and the sewage of the village of Indian Orchard, which is located on the Chicopee River within the limits of the city of Springfield, is discharged into the Chicopee River, as already stated.

The main outlets into the Connecticut River, all of which formerly discharged at the edge of the stream, caused serious nuisances at many places along the shore in the densely populated part of the city; and to remove these nuisances submerged pipes have been laid from five of the principal outlets, to convey the dry-weather flow of sewage to a point of discharge near the bottom of the river from 200 to 300 feet from shore. By this plan the nuisances formerly caused by these outlets have been removed, and no objectionable conditions were found to exist about these outlets at the times they were examined. The submerged outlets are of sufficient size to remove the dry-weather flow of sewage only, so that at times of rain or when snow is melting much mingled sewage and storm water still discharges at the old outlets at the edge of the river, but objectionable conditions have not been created by this discharge at any of the outlets. These outlets are maintained with very little trouble and expense. They occasionally become clogged, especially at periods of high water in the river, by sticks and other matters brought down from the sewage which collect near the mouth of the sewer at such times; but by removing this material from the inlet to the submerged pipe after the freshet flow has subsided, further trouble has not been experienced in keeping these outlets clear.

At all of the remaining outlets into the Connecticut River sewage discharges at the edge of the river bank, and in most cases at the ordinary stage of the river the sewage collects about the outlet or along the edge of the river for a short distance below the outlet, causing a noticeable odor of sewage in the immediate neighborhood.

The outlets into Mill River all discharge directly into the water, and, as the quantity of sewage is small, objectionable conditions were not found at these outlets at the time they were examined.

The outlet from Indian Orchard into the Chicopee River has been described under that stream.

The town of West Springfield, which had in 1900 a population of 7,105, is situated on the westerly shore of the Connecticut River, directly opposite Springfield. This town is provided with a system of combined sewers, discharging through various outlets into the Connecticut and Westfield rivers.

There are two principal outlets into the Connecticut River. The one situated above the north end bridge is built on a plan somewhat similar to the submerged outlets at Springfield, a pipe being laid beneath the bed of the river to a point well out into the stream, of sufficient size to remove the dry-weather flow of sewage, the excess of flow at times of storm discharging at about high-water mark. The submerged outlet, however, when it was examined was obstructed and was not operating, so that all of the sewage was being discharged on the shore through the storm-water outlet, creating offensive conditions.

The second outlet is situated immediately below the old wooden bridge. This outlet is a large one, and serves the village of Merrick. The sewage is discharged near the shore line at low water, but there is very little current at this place, and the water in the river is noticeably polluted for a considerable distance out from the outlet. This outlet has been the cause of serious complaint from the operatives in a factory situated on the bank of the river, and is objectionable at times to those passing over the bridge.

There is only one factory in West Springfield, wastes from which tend to seriously pollute the Connecticut River. This factory is a paper mill, situated near the lower sewer outlet. Large quantities of highly colored wastes are discharged at times into the sewer near its outlet, and the effect of the wastes is noticeable in the river for a long distance from the sewer outlet.

Just below West Springfield the Connecticut River is joined by the Westfield River, the water of which is considerably more polluted than the water of the Connecticut River.

Below the Westfield River the Connecticut River flows between the towns of Agawam and Longmeadow to the State line, receiving from the latter town sewage and sewage effluent. The town of Longmeadow, having in 1900 a population of 811, is provided with a system of sewers constructed on the separate plan. The sewage is conveyed to two filtration areas, where it is discharged on prepared sand filter beds. The filters do not receive proper attention, however, and much of the sewage does not pass through them.

The Connecticut River, where it enters Massachusetts, is practically unpolluted, and until it reaches Northampton the pollution which it receives is not sufficient to create objectionable conditions, except possibly in the immediate vicinity of the sources of pollution.

The sewage from Northampton which enters from Mill River, together with the manufacturing wastes from the sulphite pulp mills, and the sewage of Easthampton which enters from the Manhan River just below Mill River, noticeably pollute the river for a short distance.

The sewage and manufacturing wastes from Holyoke, Chicopee and Springfield have a very perceptible effect upon the character of the water; but, notwithstanding this pollution, the river as it passes into the State of Connecticut is not seriously polluted, and at Hartford, 19 miles below the State line, the water of the river has recently been used directly as a source of public water supply.

The results of special examinations of the Mill and Manhan rivers and of the Connecticut River below Northampton are given in the following tables. The average results of analyses of samples collected during the drier portions of the year for several years at Northfield near the New Hampshire line and below Springfield near the Connecticut line are also presented.

SPECIAL EXAMINATION OF MILL AND MANHAN RIVERS, JULY 14 AND 15, 1902.

[Parts per 100,000.]

SOURCE.	DAY SAMPLE.			NIGHT SAMPLE.		
	Free Ammonia	Albuminoid Ammonia.	Chlorine.	Free Ammonia	Albuminoid. Ammonia.	Chlorine.
Mill River, above main sewer outlet, Northampton,	.0920	.0370	.27	.0520	.0445	.28
Main sewer outlet, Northampton,	1.1100	.2700	4.80	.5600	.1800	1.86
Mill River, at mouth,	.1500	.0380	.46	.9800	.0780	.48
Connecticut River, below mouth of Mill River, but above "Ox Bow,"	.0148	.0224	.17	.0024	.0104	.09
Broad Brook, above Easthampton sewer outlet,	.0012	.0276	.19	.0300	.0690	.36
Easthampton sewer outlet,	1.5300	.3600	4.80	.3000	.1600	1.20
Broad Brook, at mouth,	.0324	.0512	1.07	.0380	.0590	.54
Manhan River, above Broad Brook, Easthampton,	.0084	.0164	.15	.0068	.0144	.14
Manhan River, near entrance to "Ox Bow,"	.0136	.0312	.49	.0140	.0200	.29
"Ox Bow," near outlet into Connecticut River,	.0068	.0272	.34	.0104	.0292	.42

Flow of sewage from main sewer, Northampton,	1,600,000 gallons per day.
Flow of sewage from main sewer, Easthampton,	230,000 gallons per day.
Flow of Mill River,	35 cubic feet per second.
Flow of Manhan River,	70 cubic feet per second.

SPECIAL EXAMINATION OF CONNECTICUT RIVER, SEPT. 16 AND 17, 1902.

[Parts per 100,000.]

SOURCE.	Free Ammonia.	Albuminoid Ammonia.	Chlorine.
Connecticut River, above Northampton,	.0028	.0128	.09
Mill River, at mouth,	.0800	.0368	.43
Manhan River, at mouth,	.0048	.0188	.26
Connecticut River, below Manhan River,	.0030	.0135	.10
Connecticut River, above Holyoke dam,	.0031	.0160	.11
Connecticut River, below Holyoke,	.0042	.0234	.14
Chicopee River, at mouth,	.0060	.0236	.31
Connecticut River, below Chicopee,	.0040	.0193	.17
Connecticut River, below Springfield, but above Westfield River,	.0021	.0210	.16
Westfield River, at mouth,	.0026	.0232	.29
Connecticut River, below Westfield River,	.0038	.0183	.17

CHEMICAL EXAMINATION OF WATER FROM THE CONNECTICUT RIVER. — AVERAGES FOR SIX MONTHS, FROM JUNE TO NOVEMBER, INCLUSIVE.

Connecticut River, at Northfield.

[Parts per 100,000.]

YEAR.	Color.	RESIDUE ON EVAPORATION.		AMMONIA.				Chlorine.	NITROGEN AS		Oxygen Consumed.	Hardness.
		Total.	Loss on Ignition.	Free.	ALBUMINOID.				Nitrates.	Nitrites.		
					Total.	Dissolved.	Sus-pended.					
1887,	.43	6.46	1.32	.0038	.0144	–	–	.11	.0066	–	–	–
1888,	.28	5.63	1.20	.0044	.0139	.0118	.0021	.11	.0108	.0006	–	–
1899,	.30	7.32	2.17	.0016	.0189	.0158	.0031	.11	.0023	.0001	.85	3.6
1900,	.47	6.24	2.11	.0023	.0190	.0154	.0036	.09	.0030	.0001	.95	2.9
1901,	.31	6.12	2.39	.0016	.0146	.0122	.0024	.10	.0037	.0002	.72	3.2
1902,	.30	5.57	2.02	.0014	.0124	.0110	.0014	.08	.0057	.0001	.60	2.9

Connecticut River, below Springfield.

1888,	.35	5.34	1.24	.0032	.0182	.0143	.0039	.15	.0082	.0002	–	–
1899,	.33	6.61	1.99	.0093	.0238	.0195	.0043	.23	.0042	.0003	.67	3.1
1900,	.44	6.64	1.90	.0098	.0250	.0176	.0074	.20	.0034	.0002	.89	3.1
1901,	.32	6.03	2.34	.0061	.0190	.0153	.0037	.18	.0048	.0003	.65	3.0
1902,	.31	5.83	2.13	.0062	.0180	.0140	.0040	.16	.0055	.0005	.61	3.0

DEERFIELD RIVER.

The Deerfield River is a tributary of the Connecticut River from the west, rising in the State of Vermont, and draining the northerly section of Massachusetts west of the Connecticut River, which is rugged and mountainous. The river falls very rapidly throughout nearly all of its course, and, as there are very few ponds on the water-shed, the flow of the stream is subject to great fluctuations.

The following tables give data in regard to the drainage areas at various points and the population upon the water-shed: —

LOCALITY.	Distance above Mouth (Miles).	Drainage Area (Square Miles).	Population on Drainage Area.	Population per Square Mile.	Estimated Population discharging Sewage into River.
Just above north branch, at Shelburne Falls,	18.0	405.9	7,600	19	160
North branch, at mouth,	18.0	93.0	2,600	28	400
Just below north branch, at Shelburne Falls,	18.0	498.8	10,200	21	560
Just above Green River, at Deerfield,	2.1	574.5	14,900	26	1,660
Green River, at mouth,	2.1	89.8	9,300	103	6,000
Deerfield River, at mouth,	0	666.5	24,300	36	7,660

CITIES AND TOWNS, CONSIDERABLE PORTIONS OF WHICH ARE WITHIN THE WATER-SHED OF THE DEERFIELD RIVER.

CITY OR TOWN.	Population in 1900.	Sewerage System.	Estimated Population discharging Sewage into River.	Manufactories discharging Wastes into River.
Somerset, Vt.,	67	None.	0	None.
Searsburg, Vt.,	161	None.	0	None.
Wilmington, Vt.,	1,221	None.	0	None.
Readsborough, Vt.,	1,139	None.	Unknown.	One tannery, one paper mill.
Whittingham, Vt.,	1,042	None.	0	None.
Marlborough, Vt.,	448	None.	0	None.
Halifax, Vt.,	662	None.	0	None.
Guilford, Vt.,	782	None.	0	None.
Monroe,	305	None.	60	One paper mill.
Florida,	390	None.	0	None.
Rowe,	549	None.	0	None.
Savoy,	506	None.	0	None.
Hawley,	429	None.	0	None.
Charlemont,	1,094	Partial.	100	None.
Ashfield,	955	None.	0	None.
Buckland,	1,446	Partial.	350	None.
Heath,	441	None.	0	None.
Colrain,	1,749	None.	400	One cotton mill.
Shelburne,	1,508	Partial.	600	None.
Conway,	1,458	None.	150	One cotton mill.
Deerfield,	1,969	None.	0	None.
Leyden,	379	None.	0	None.
Greenfield,	7,927	General.	6,000	One cutlery factory.

Within the State of Vermont the Deerfield River receives pollution from a tannery and a paper mill in Readsborough about 3 miles above the Massachusetts line. In Massachusetts the first source of pollution is in Monroe, where the river receives sewage and manufacturing wastes from a paper mill employing about 60 persons. The river is not seriously affected by this pollution except immediately below the mill.

At Shelburne Falls the river is joined by North River, which receives pollution in Colrain, about 3 miles above its mouth, from three cotton mills employing about 270 persons. The quantity of wastes discharged from these mills is small, but all of the sewage from them goes directly into the stream, together with the sewage from about 40 houses.

At Shelburne Falls, on the Buckland side of the river, sewage is discharged from a factory in which 250 persons are employed, and on the Shelburne side of the river sewage from 50 employees in a factory is discharged into the stream. Neither Shelburne Falls nor Buckland is provided with a sewerage system, but there is a small sewer in Buckland, discharging into the river below the water level; and there is a sewer in Shelburne, receiving the sewage from about 100 buildings, discharging about 700 feet below the dam beneath the surface of the water at all times except at the lowest stage of the river. These outlets do not appear to be objectionable, and the effect of the sewage is not noticeable.

A short distance below Shelburne the river is joined from the south by South River, one of the largest tributaries. This stream flows through the town of Conway, where it receives sewage from a shoe shop in which 83 persons are employed, and sewage and manufacturing wastes from a cotton mill employing about 55 persons.

Below the South River the Deerfield River flows through the town of Deerfield into Greenfield. At Greenfield it is joined by Green River, a large tributary from the north, which flows near the central portion of the village of Greenfield, and receives all of the sewage from this village. The town of Greenfield had in 1900 a population of 7,927. The town is quite thoroughly sewered, and the sewage from about 6,000 people is discharged into the river through several outlets. The upper principal sewer outlet discharges just above a small mill pond and the lower principal outlet just above a second mill pond. The water of the river is very badly polluted, and. as the water in the ponds is subject to considerable fluctuations in elevation, local nuisances have been produced which have been the source of complaints. There is a large population in the vicinity of these ponds and along the stream below the ponds.

Below the Greenfield sewer outlets the Green River flows for about a mile and discharges into the Deerfield River, where it is diluted by a large flow of comparatively pure water in the latter stream.

A special examination was made of Green River July 16 and 17, 1902, the results of which are given in the following table: —

SPECIAL EXAMINATION OF GREEN RIVER, AT GREENFIELD, JULY 16 AND 17, 1902.

[Parts per 100,000.]

SOURCE.	DAY SAMPLE.			NIGHT SAMPLE.		
	Free Ammonia.	Albuminoid Ammonia.	Chlorine.	Free Ammonia.	Albuminoid Ammonia.	Chlorine.
Green River, above Greenfield sewer outlets,	.0012	.0092	.08	.0012	.0088	.13
Shelburne Street sewer outlet,	2.4300	.5100	6.35	.5500	.2200	4.25
Green River, at Mill Street, between main sewer outlets,	.0216	.0244	.18	.0128	.0158	.18
Bank Row sewer outlet,	1.7800	.3900	35.60	.3500	.1300	5.30
Green River, near mouth, ¾ mile below Bank Row sewer outlet,	.0256	.0296	.41	.0224	.0220	.28

Flow of sewage from Shelburne Street sewer,	155,000 gallons per day.
Flow of sewage from Bank Row sewer,	100,000 gallons per day.
Flow of river,	45 cubic feet per second.

CHEMICAL EXAMINATION OF WATER FROM THE DEERFIELD RIVER. — AVERAGES FOR SIX MONTHS, FROM JUNE TO NOVEMBER, INCLUSIVE.

Deerfield River, at Shelburne Falls.

[Parts per 100,000.]

YEAR.	Color.	RESIDUE ON EVAPORATION.		AMMONIA.				Chlorine.	NITROGEN AS		Oxygen Consumed.	Hardness.
					ALBUMINOID.							
		Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Sus-pended.		Nitrates.	Nitrites.		
1894,	.42	3.77	1.03	.0004	.0127	.0111	.0016	.15	.0012	.0000	.48	1.7
1895,	.40	3.96	1.31	.0013	.0153	.0128	.0025	.12	.0053	.0001	.56	1.8
1901,	.34	4.02	1.82	.0057	.0200	.0171	.0029	.09	.0078	.0001	.63	1.7
1902,	.29	3.62	1.46	.0051	.0151	.0126	.0025	.08	.0055	.0002	.51	1.7

Deerfield River, at Deerfield.

1901,*	.23	4.35	1.58	.0011	.0121	.0109	.0012	.10	.0080	.0001	.38	2.1

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* June, September and November.

FRENCH RIVER.

The French River rises in the town of Leicester and flows in a southerly direction into the State of Connecticut, where it joins the Quinebaug River and finally discharges into Long Island Sound. The river has a small water-shed in Massachusetts, but there are numerous ponds and storage reservoirs upon it, so that the summer flow is high and the numerous falls are used for manufacturing purposes.

The following tables give statistics relative to the drainage areas and the population upon them at various points: —

LOCALITY.	Distance above State Line (Miles).	Drainage Area (Square Miles).	Population on Drainage Area.	Population per Square Mile.	Estimated Population discharging Sewage or Sewage Effluent into River.
French River, above Mill Brook, Webster, .	3.5	73.8	6,100	83	2,530
Mill Brook, at mouth, ...	3.5	10.4	1,400	135	200
French River, below Mill Brook, . . .	3.5	84.2	7,500	89	2,730
French River, at State line, ...	0.0	93.1	14,300	154	9,730

TOWNS, CONSIDERABLE PORTIONS OF WHICH ARE WITHIN THE WATER-SHED OF THE FRENCH RIVER.

TOWN.	Population in 1900.	Sewerage System.	Estimated Population discharging Sewage or Sewage Effluent into River.	Manufactories discharging Wastes into River.
Leicester, ...	3,416	General.*	2,300	Two woolen mills, one cotton mill, one knife shop.
Oxford, ...	2,677	None.	200	One woolen mill, two satinet mills.
Charlton, . . .	1,860	None.	30	None.
Dudley, ...	3,553	Partial.	1,200	Three woolen mills, one linen mill.
Webster, . . .	8,804	General.	6,000	One bleachery, one woolen mill.

* Sewage purification works in use.

The first source of pollution is at Leicester, where the stream receives the effluent, and at times unpurified sewage from the Leicester sewerage system. The town of Leicester had in 1900 a population of 3,416. The main village is provided with a separate system of sewers. The sewage is conveyed to a filtration area near one of the tributaries of the French River, where it is passed through settling tanks and then discharged on prepared filter beds or into trenches on the slope of a hill. At times a portion of the sewage finds its way into the brook without purification.

The next sources of pollution are at the villages of Greenville and Rochdale in the town of Leicester, where the river receives sewage from four mills employing about 225 persons. From these factories water used for washing and dyeing cotton and woolen cloth, and wool-scouring liquor from washing about 25,000 pounds of wool per week, are discharged directly into the stream, making the water noticeably polluted. The river also receives in these villages sink drainage from a considerable population.

At Larnedville in the town of Oxford, and at North Oxford, 1.5 miles below, there are satinet mills employing 55 and 240 persons respectively, sewage from which, together with water used for washing and dyeing, is discharged into the river. At the latter mill 8,000 pounds of cloth are washed and dyed daily. About a mile below North Oxford the sink drainage and a portion of the sewage from a factory employing about 75 persons, and at a short distance below this the sewage from a factory employing 30 persons, are discharged into the river.

In Oxford there are two woolen mills employing about 120 persons, sewage and wastes from which are discharged into the river. In one of these establishments no wool is scoured at present, but in the other about 1,000 pounds are scoured daily.

The next principal sources of pollution are in the towns of Webster and Dudley, the former being on the easterly side and the latter on the westerly side of the river. In these towns the river has a rapid fall, and there are numerous mill ponds and factories.

The river receives just above the village of Webster the flow from Lake Chaubunagungamaug. This lake has an area of 1,250 acres and a watershed of about 9.7 square miles. During dry weather large quantities of water are drawn from this lake to increase the flow of the river.

On Mill Brook, which forms the outlet of the lake, is situated a bleaching, dyeing and printing mill, employing about 200 persons, sewage and wastes from which are discharged into the stream. The quantity of cloth dyed and bleached amounts to about 100,000 pounds each week, and the water of the brook is highly colored and opaque from the spent dyes discharged into it, and the bed and shores of the stream are also discolored.

A large cotton mill employing 800 persons is situated on the French River just below the entrance of Mill Brook, the sink drainage from which is discharged into the stream, but no liquid wastes are produced at this place.

A short distance below this cotton mill there are two woolen mills, one of which produces no liquid wastes, but discharges the sewage from about 50 persons into the river. At the other 850 persons are employed and 10,000 pounds of wool are scoured daily. The wool-scouring wastes are treated for the removal of a portion of the grease, the remainder being discharged directly into the stream. Enormous quantities of spent dyes and water from washing cloth are also discharged into the stream, as well as the sink drainage from all of the operatives and the sewage from a considerable portion of them.

On the Dudley side of the river, opposite the village of Webster, are a linen and a woolen mill. At the former, sewage from 625 operatives and large quantities of bleaching wastes and wash water are discharged into a brook just above its junction with the river; at the latter mill, situated on the main river, sink drainage from 350 operatives and large quantities of wool-scouring waste, water used for washing cloth and spent dyes are discharged into the stream.

Below the main village of Webster near the line between Massachusetts and Connecticut there are two woolen mills, both in the town of Dudley. From one of these mills water used for washing the finished product is discharged into a brook about a quarter of a mile above its junction with the river; and at the other mill sewage from 165 persons, wastes from scouring about 1,000 pounds of wool daily, spent dyes and water used for washing cloth are discharged directly into the stream.

In addition to the sewage and wastes from the factories, the river receives the domestic sewage of the town of Webster and of a portion of the town of Dudley.

The town of Webster had in 1900 a population of 8,804, and is provided with a fairly complete system of sewers. The sewers are designed to take sewage only, and at present discharge into the river through five outlets. The principal outlet is at a bridge on the main street, in the vicinity of a large population. The outlet discharges beneath the surface into deep water, and whenever it has been examined the river below was not noticeably affected by the sewage. At times in summer the water is held back by the dams above the sewer outlet, and the water in the mill pond below is drawn down so that deposits of solid matter which have accumulated below the outlet are exposed, and are said to create a great nuisance. The other four outlets are small ones, serving only a limited population, and no serious local nuisances appear to be created by them. Plans have been prepared for the purification of the sewage of Webster on filter beds to be located near the river below the village.

There is no complete system of sewers in Dudley, but small sewers have been constructed which serve a population of perhaps 300. These sewers discharge into the river near the highways; but the quantity of sewage is so small that the outlets are not noticeably objectionable at present, and the condition of the river, due to the presence of manufacturing wastes, is such that the effect of the additional amount of sewage cannot be detected.

The river above Webster is noticeably polluted at several points, but immediately above the village the water is not objectionable in appearance or odor. Mill Brook, which enters just above Webster, contributes a large flow of highly polluted and badly discolored water to the river; and at the large woolen mills enormous quantities of wastes containing much organic matter are discharged into the stream, making it very objectionable; and the numerous mill ponds on the stream, the level of the water in which is subject to considerable variations, tend to increase the objectionable conditions, as at times large areas of the bottom are exposed.

The results of special examinations of the French River and the average results of regular analyses of the stream are given in the tables which follow: —

SPECIAL EXAMINATION OF FRENCH RIVER AT WEBSTER, SEPT. 10, 1901.

[Parts per 100,000.]

Source.	Morning Sample.			Afternoon Sample.		
	Free Ammonia.	Albuminoid Ammonia.	Chlorine.	Free Ammonia.	Albuminoid Ammonia.	Chlorine.
French River, above Mill Brook,	.0012	.0256	.22	.0020	.0264	.18
Mill Brook, near mouth,	.0004	.0324	.15	.0012	.0256	.22
French River, below Mill Brook, but above sewer outlets,	.0012	.0268	.21	.0016	.0284	.22
Merino Brook, near mouth,	.0056	.0756	.60	.0032	.0752	.56
French River, at State line (below second mill pond),	.0164	.0560	.34	.0036	.0428	.24

Flow of river, ... 193 cubic feet per second.

CHEMICAL EXAMINATION OF WATER FROM THE FRENCH RIVER. — AVERAGES FOR SIX MONTHS, FROM JUNE TO NOVEMBER, INCLUSIVE.

French River, above Webster.

[Parts per 100,000.]

Year.	Color.	Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
					Albuminoid.							
		Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		
1902,	.43	4.98	2.05	.0062	.0351	.0238	.0113	.41	.0033	.0002	.60	1.1

French River, below Webster.

Year.	Color.	Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
					Albuminoid.							
		Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		
1899,	.44	5.67	2.07	.0238	.0612	.0384	.0228	.42	.0024	.0007	.66	1.6
1900,	.52	5.79	2.10	.0202	.0475	.0357	.0118	.46	.0062	.0007	.78	1.5
1901,	.50	5.29	2.25	.0090	.0390	.0265	.0125	.33	.0044	.0002	.75	1.2
1902,	.42	4.92	1.99	.0057	.0391	.0264	.0127	.39	.0038	.0002	.65	1.2

HOOSICK RIVER.

The Hoosick River, a tributary of the Hudson, is formed by the junction of the north and south branches in the central portion of the city of North Adams, whence it flows north-westerly through Williamstown, and across the south-western corner of Vermont to the Hudson River in the State of New York.

The following tables give data in regard to the drainage areas and the population upon the drainage areas at various places: —

LOCALITY.	Distance above State Line (Miles).	Drainage Area (Square Miles).	Population on Drainage Area.	Population per Square Mile.	Estimated Population discharging Sewage into River.
South branch, above Adams,	16.5	36.3	1,400	39	0
South branch, about 2 miles below Adams,	13.0	63.1	11,900	189	4,500
South branch, at mouth,	7.5	75.1	23,400	312	5,000
North branch, at mouth,	7.5	43.4	10,600	244	300
Total, at confluence,	7.5	118.5	34,000	287	5,300
Hoosick River, at outlet of main sewer in North Adams.	7.2	118.9	35,200	296	27,775
Hoosick River, at Williamstown,	2.6	177.2	41,900	236	29,775

CITIES AND TOWNS, CONSIDERABLE PORTIONS OF WHICH ARE WITHIN THE WATER-SHED OF THE HOOSICK RIVER.

CITY OR TOWN.	Population in 1900.	Sewerage System.	Estimated Population discharging Sewage into River.	Manufactories discharging Wastes into River.
Cheshire,	1,221	None.	0	None.
Adams,	11,134	Private sewers.	4,500	Five cotton mills, one paper mill, one woolen mill.
North Adams,	24,200	General.	23,000	One cotton mill, two print works, two woolen mills, one leather factory.
Stamford, Vt.,	677	None.	0	None.
Clarksburg,	943	None.	275	One woolen mill.
New Ashford,	107	None.	0	None.
Williamstown,	5,013	Partial.	2,000	Two cotton mills.

The only town in the water-shed of the south branch which contributes any considerable quantity of sewage or manufacturing wastes to the river is Adams, located about 7 miles above the junction of the two branches. At this place sewage and manufacturing wastes are discharged into the river from cotton mills employing about 3,700 persons, from a paper mill employing about 300 persons, and from a woolen mill employing about 100 persons. The quantity of manufacturing wastes from the cotton mills is not large, and consists chiefly of spent dyes; that from the paper mills consists of wastes from the washers and paper machines; and that from the woolen mills consists of the wool-scouring liquors and wastes from washing cloth.

The town is not provided with a sewerage system, but there is a large number of private sewers discharging into the river, and many privies are situated over the river and on the edge of the canals. Many of the outlets of the private sewers produce offensive conditions in the immediate vicinity, and are otherwise objectionable. From the information available, it appears that the sewage from about 4,500 persons is discharged into the river.

In North Adams the south branch receives sewage from two small sewers, each serving about 25 houses, and sewage from a factory employing about 150 persons.

The south branch above Adams is practically an unpolluted stream. Below Adams the water is polluted, and is somewhat objectionable in appearance and odor.

The water-shed of the north branch contains no sources of pollution above North Adams except a woolen mill situated in Clarksburg, in which about 275 persons are employed, and 900,000 pounds of wool are scoured each year. On the north branch within the city of North Adams there are several large factories, but the sewage and manufacturing wastes are now discharged into the city sewers. A small quantity of spent dyes from the print works is discharged into the stream. There are several dams on this branch, and at times of dry weather the bed of the river in places is practically dry except for pools of water which remain among the stones, the main flow of the river passing through the canals. This condition has been the cause of a serious nuisance. Near the junction of the two branches the river receives the wastes from a print works employing about 1,400 persons. These wastes consist chiefly of spent dyes and water used for washing.

At its mouth the north branch is badly polluted, and the water is of about the same character as that of the south branch. Between the junction of the branches and the outlet of the North Adams main sewer the river receives sewage and manufacturing wastes from a factory employing about 500 persons. The manufacturing wastes are those from the processes of bleaching and dyeing.

North Adams had a population in 1900 of 24,200, and the estimated population in 1902 is 26,200. The city is very thoroughly sewered on the separate plan, and it is estimated that the total population connected with the sewers is about 23,000.

The main portion of the sewage is discharged into the river about a mile below the junction of the two branches, but there are several other outlets, each serving a very small area. The main sewer was constructed in 1891. The outlet is located at the edge of the river, at a place where the current is divided, about half of the flow passing through the channel which receives the sewage. The current into which the sewage discharges is very rapid, and the sewage is carried quickly away at times when there is considerable water flowing in the river; but at times of dry weather there are periods, when the mills above are not in operation, when practically all of the water is held back by the dams, and there is very little flow in the stream. At such times the sewage collects in pools, and a great nuisance results. There are several houses not far from the sewer outlet.

Below the sewer outlet the river flows through the village of Braytonville, two-thirds of a mile distant, at which place it receives the sewage and manufacturing wastes from a woolen mill employing about 240 persons, and scouring about 1,000,000 pounds of wool yearly. At the village of Greylock, 1.5 miles below the sewer outlet, sewage from a cotton mill employing about 225 persons is discharged into the stream; and at Blackinton, on the line between North Adams and Williamstown, 2½ miles below the sewer outlet, the river receives sewage and wastes from a woolen mill employing about 350 persons, and scouring about 200,000 pounds of wool per year. At each of these three villages there is a small mill pond, subject to considerable fluctuations in level, and there is a large population close to the river.

The condition of the stream immediately below the North Adams sewer outlet is very offensive, and its appearance is that of sewage. Its condition improves somewhat further down stream, notwithstanding the added pollution entering it from the various villages.

At Williamstown, 4 miles below the North Adams sewer outlet, there is a large mill pond having an area of 45 acres. Just above this mill pond the river is joined by Green River, having a water-shed of 43 square miles.

The population of Williamstown in 1900 was 5,013. The town has no complete sewerage system, but there are several sewers which take sewage and a considerable quantity of storm water, and discharge at convenient points.

Two of the sewers discharge into Green River, and the remaining sewers discharge into the Hoosick River below the mill pond. The sewer outlets into Green River are beneath the surface of the water at some distance from the shore, and no offence is caused by them. One sewer outlet discharges by a highway bridge near the railroad station of the Boston & Maine Railroad. This outlet is submerged, and its presence cannot ordinarily be detected. There are two other outlets into the river below, at points remote from any population.

On Green River there is a cotton mill employing 95 persons, from which sewage and manufacturing wastes are discharged into the stream; and into the main river just below Green River sewage and wastes are discharged from another cotton mill employing 225 persons. The wastes consist chiefly of spent dyes.

A special examination of the Hoosick River and its branches was made on Sept. 2 and 3, 1902, at a time when the flow of the river was considerably in excess of the dry-weather flow. The results of the analyses, which are given in the following table, show plainly the effect of the sewage of Adams and North Adams on the water.

SPECIAL EXAMINATION OF HOOSICK RIVER, SEPT. 2 AND 3, 1902.

[Parts per 100,000.]

SOURCE.	DAY SAMPLE.				NIGHT SAMPLE.			
	Free Ammonia.	Albuminoid Ammonia.	Chlorine.	Dissolved Oxygen.	Free Ammonia.	Albuminoid Ammonia	Chlorine.	Dissolved Oxygen.
South branch, above Adams,	.0040	.0192	.07	-	.0040	.0168	.07	-
South branch, below Adams,	.0040	.0364	.27	-	.0068	.0284	.38	-
South branch, just above North Adams,	.0088	.0268	.25	-	.0160	.0260	.24	-
South branch, at mouth,	.2200	.0730	1.94	-	.0036	.0392	.56	-
North branch, above North Adams,	.0036	.0320	.10	-	.0028	.0264	.09	-
North branch, at mouth,	.0032	.0548	.56	-	.0032	.0372	.29	60.0
Hoosick, above main sewer outlet, North Adams,	.0045	.0735	.89	-	.0204	.0284	.35	-
Sewage from main sewer outlet,	1.4000	.5200	2.95	-	.6800	.2040	4.60	-
Hoosick, 600 feet below main sewer outlet,	.2040	.2850	1.55	35.3 33.3	.2200	.1950	.88	53.8 27.8
Hoosick, 2 miles below main sewer outlet,	.0052	.0584	.62	52.5 48.2	.0056	.0584	.49	58.8 55.5
Hoosick, 3 miles below main sewer outlet,	.0052	.0592	.55	49.6 61.8	.0040	.0572	.51	-
Green River, above Williamstown village,	.0026	.0080	.10	-	.0034	.0122	.10	-
Green River, at mouth,	.0052	.0154	.17	-	.0084	.0140	.15	-
Hoosick, below Williamstown mill pond,	.0168	.0388	.42	41.7	.0500	.0296	.39	60.6

Flow of sewage from main sewer in North Adams, 2,000,000 gallons per day.

Analyses of the water of the river just below Williamstown have been made regularly each month for a long period of years, and monthly analyses have been made of the river and its branches at various places during the drier portion of each year. The following tables give the averages of these analyses during the six months from June to November, inclusive, of each year. In 1902 the rainfall in this period and flow of the stream was much higher than in previous years, and the effect is clearly shown by the analyses.

CHEMICAL EXAMINATION OF WATER FROM HOOSICK RIVER AND ITS BRANCHES. — AVERAGES FOR SIX MONTHS, FROM JUNE TO NOVEMBER, INCLUSIVE.

South Branch, above Adams.

[Parts per 100,000.]

YEAR.	Color.	RESIDUE ON EVAPORATION.		AMMONIA.				Chlorine.	NITROGEN AS		Oxygen Consumed.	Hardness.
					ALBUMINOID.							
		Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		
1901,	.11	10.06	2.44	.0030	.0141	.0115	.0026	.10	.0067	.0010	.34	8.2
1902,	.20	8.19	2.32	.0026	.0143	.0119	.0024	.08	.0070	.0001	.36	5.8

South Branch, below Adams.

1901,	.15	11.26	3.24	.0035	.0188	.0129	.0059	.24	.0220	.0037	.36	8.1
1902,	.21	10.42	3.18	.0031	.0208	.0132	.0076	.21	.0345	.0011	.35	6.4

South Branch, at Mouth.

1898,	.25	10.27	2.38	.0055	.0248	.0159	.0089	.19	.0235	.0007	.35	7.5
1899,	.18	12.95	2.65	.0078	.0332	.0212	.0120	.33	.0182	.0012	.31	9.3
1900,	.14	14.02	2.57	.0158	.0357	.0170	.0187	.35	.0220	.0021	.26	9.3
1901,	.16	13.47	3.77	.0135	.0431	.0217	.0214	.40	.0272	.0012	.38	9.2
1902,	.22	10.15	2.81	.0049	.0214	.0139	.0075	.19	.0197	.0011	.35	7.2

North Branch, at Mouth.

1898,	.56	10.51	3.04	.0108	.0415	.0233	.0182	.65	.0252	.0011	.98	4.4
1899,	–	17.37	4.12	.0107	.0627	.0292	.0335	1.10	.0092	.0038	1.48	5.8
1900,	.66	16.29	4.16	.0073	.0540	.0269	.0271	1.23	.0032	.0034	1.43	6.0
1901,	.31	19.81	5.82	.0112	.0606	.0284	.0322	1.46	.0057	.0038	1.94	6.3
1902,	.32	12.99	3.64	.0036	.0399	.0239	.0160	.55	.0097	.0022	.86	5.5

Hoosick River, a Mile below the Outlet of the North Adams Main Sewer.

1898,	.29	10.79	2.84	.0050	.0379	.0210	.0169	.33	.0142	.0014	.46	6.9
1901,	.24	12.62	3.72	.0237	.0542	.0244	.0298	.45	.0208	.0024	.62	7.4
1902,	.25	10.98	3.27	.0094	.0380	.0190	.0190	.39	.0150	.0025	.62	5.6

CHEMICAL EXAMINATION OF WATER FROM HOOSICK RIVER AND ITS BRANCHES. — AVERAGES FOR SIX MONTHS, FROM JUNE TO NOVEMBER, INCLUSIVE — *Concluded.*

Hoosick River, at Williamstown.

[Parts per 100,000.]

YEAR.	Color.	RESIDUE ON EVAPORATION.		AMMONIA.				Chlorine.	NITROGEN AS		Oxygen Consumed.	Hardness.
					ALBUMINOID.							
		Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		
1887, ...	.22	12.05	1.22	.0065	.0190	–	–	.23	.0232	–	–	–
1888, ...	.12	10.82	1.90	.0026	.0210	.0142	.0068	.27	.0247	.0015	–	–
1894, ...	.37	13.56	2.74	.0166	.0361	.0224	.0137	.50	.0102	.0014	.42	9.0
1895, ...	.34	14.20	3.26	.0190	.0424	.0241	.0183	.63	.0090	.0020	.53	9.0
1896, ...	.21	11.71	2.39	.0295	.0267	.0172	.0095	.39	.0133	.0018	.33	8.6
1897, ...	.26	11.32	2.39	.0174	.0312	.0173	.0139	.30	.0265	.0011	.31	7.9
1898, ...	.27	10.46	2.38	.0223	.0311	.0210	.0101	.31	.0170	.0007	.34	6.6
1899, ...	.30	15.21	3.31	.0252	.0622	.0379	.0243	.64	.0070	.0029	.62	8.3
1900, ...	.28	14.20	2.79	.0433	.0547	.0301	.0246	.60	.0087	.0043	.58	7.8
1901, ...	.27	13.02	3.70	.0400	.0520	.0250	.0270	.43	.0152	.0024	.53	7.3
1902, ...	.22	10.62	2.87	.0069	.0307	.0172	.0135	.34	.0123	.0014	.40	6.4

HOUSATONIC RIVER.

The Housatonic River is formed by the junction of the east, west and south-west branches, just below the thickly built up portion of the city of Pittsfield. It flows in a southerly direction through Berkshire County into the State of Connecticut, and thence into Long Island Sound.

The following tables give data in regard to the drainage areas and the population on the drainage areas at various points: —

LOCALITY.	Distance above State Line (Miles).	Drainage Area (Square Miles).	Population on Drainage Area.	Population per Square Mile.	Estimated Population discharging Sewage or Sewage Effluent into River.
East branch, below Dalton, ...	50.2	55.2	3,900	71	1,700
East branch, at mouth, ...	44.1	70.2	13,400	191	1,700
West branch, at mouth, ...	44.1	35.8	10,200	285	7,000
South-west branch, at mouth, ...	44.7	22.7	2,700	119	400
Total of the three branches, at confluence, .	–	129.0	26,600	206	9,100
Housatonic River, at Lenox station, . .	37.0	168.0	28,400	169	21,700
Housatonic River, below Stockbridge, . .	23.6	275.1	36,800	134	25,600
Housatonic River, below Great Barrington, .	15.2	329.0	43,400	132	29,100
Housatonic River, at State line, ...	0.0	527.0	49,400	94	29,230

CITIES AND TOWNS, CONSIDERABLE PORTIONS OF WHICH ARE WITHIN THE WATER-SHED OF THE HOUSATONIC RIVER.

CITY OR TOWN.	Population in 1900.	Sewerage System.	Estimated Population discharging Sewage or Sewage Effluent into River.	Manufactories discharging Wastes into River.
Hinsdale, ...	1,485	Partial.	500	One woolen mill.
Dalton, ...	3,014	Partial.	1,200	Five paper mills, one woolen mill, one shoe shop.
Pittsfield, ...	21,766	General.*	20,000	Six woolen mills, one cotton mill.
Lanesborough, . .	780	None.	0	None.
Washington, . . .	377	None.	0	None.
Lenox, ...	2,942	General.*	2,000	One paper mill.
Lee, ...	3,596	Partial.	700	Seven paper mills, one machine shop.
Tyringham, . . .	386	None.	0	None.
Stockbridge, . . .	2,081	General.*	1,200	None.
Richmond, . . .	679	None.	0	None.
West Stockbridge, .	1,158	None.	0	None.
Great Barrington, .	5,854	General.	3,500	Three cotton mills, one paper mill, one instrument factory.
Alford, ...	272	None.	0	None.
Egremont, . . .	758	None.	0	None.
Sheffield, ...	1,804	Few sewers.	30	None.
Monterey, ...	455	Private sewers.	100	None.
New Marlborough, .	1,282	None.	0	None.

* Sewage purification works in use.

The water-shed of the east branch contains the towns of Hinsdale and Dalton and a portion of the city of Pittsfield.

Hinsdale, situated 11 miles above the junction of the branches, had a population in 1900 of 1,485. It is not provided with a regular system of sewerage, but the sewage from a population of about 300 is discharged into the river through storm-water drains or private sewers. The sewer on Main Street discharges on the bank of the river at a considerable distance from the water. The odor from the sewage discharged upon the ground is at times very objectionable. The other outlets have not given any serious trouble. The river receives the wastes from a woolen mill in which 225 persons are employed, and about 1,200,000 pounds of wool are scoured yearly.

At Dalton, 7 miles above the junction of the branches, there are two sewers, through which the sewage of about 600 persons is discharged directly into the river. Both of these sewers discharge on the bank of the river a considerable distance above the ordinary level of the water, and the conditions in the immediate vicinity of the outlets are objectionable. There is no population near either of the outlets. Sewage and manufacturing wastes from five large paper mills employing about 650 persons, and a woolen mill employing about 150 persons, in which cloth is washed and dyed, are discharged directly into the stream.

Within the city of Pittsfield the east branch receives very little pollution, except street washings and the sewage from a few houses discharged through a storm-water drain at Pomeroy Avenue.

The water of the east branch above Hinsdale is practically unpolluted. Immediately below the woolen mill at Hinsdale it is badly polluted, but its appearance improves until it reaches Dalton, where the sewage and manufacturing wastes discolor the river and give it an objectionable appearance, but the odor from it is not offensive. Its condition improves rapidly and at its mouth this branch shows little evidence of the pollution which it receives.

The west and south-west branches receive practically no pollution except within the limits of the city of Pittsfield.

The population of Pittsfield in 1902 is estimated to be 22,300. The main portion of the city is very thoroughly sewered, and the population connected with the sewers is estimated to be 18,000.

The greater part of the city is sewered on the separate plan, and in the latter part of the year 1902 works for the purification of the sewage collected by the separate system of sewers were completed. A considerable area of the city, however, is sewered by an old system of storm-water drains, which has an outlet into the west branch just below the thickly built up section of the city. The quantity of sewage discharged from this sewer at times when there is no storm water amounts to from 650,000 to 1,000,000 gallons per day. The sewage is discharged at the edge of the river, and its effect is noticeable for a long distance below the point of discharge, but there are no dwelling houses in the immediate vicinity of the outlet.

Sewage and manufacturing wastes from six woolen mills, in which 1,725 persons are employed and about 8,500 pounds of wool are scoured per day, are discharged into the branches of the river above the most thickly settled portions of the city. The wastes from these mills consist chiefly of wool-scouring liquors, water used for washing the cloth and spent dyes. There is also a cotton mill employing 50 persons, from which sewage and spent dyes are discharged into the stream.

All but one of these mills are upon the west branch, and, as these factories are many of them situated above the thickly settled portion of the city, the effect of the discharge of sewage and wastes into the streams is to make the west branch objectionable in appearance, and to give it an offensive odor where it passes through the city. The west branch at its mouth is badly polluted, and objectionable in appearance and odor, especially at times of low flow in the stream.

The south-west branch is seriously polluted by sewage and wastes from a large woolen mill, but below the woolen mill it flows through a practically uninhabited country to its mouth.

Below Pittsfield the Housatonic River flows for a distance of about seven miles to Lenox station through a sparsely settled territory. In this portion of its course it receives the effluent from the sewage purification works of Pittsfield. At these works all of the sewage collected in the separate system of sewers, amounting to about 1,800,000 gallons per day, is purified on sand filter beds, and the effluent is discharged into the river. At Lenox station the river receives sewage from the town of Lenox.

Lenox, which had a population in 1900 of 2,942, has a general system of sewers constructed upon the separate plan. The sewage is delivered on the side of a hill near the river below Lenox station, where works have been constructed for its purification by broad and subsurface irrigation. A connection is made directly with the river, however, through which all of the sewage of the town is discharged during a large part of the time. At other times some of the sewage discharged upon the area finds its way over the surface of the ground and flows eventually into the river. The outlet into the river is located just above a dam, which forms a large mill pond and is beneath the surface of the water. Within the town of Lenox there is one small paper mill employing about 15 persons and discharging sewage and a small quantity of manufacturing waste into the river.

The next town upon the river is Lee, which is about 11 miles below Pittsfield. This town had a population in 1900 of 3,596. The main village of Lee is quite thoroughly sewered, the sewers being constructed on the separate plan, except that one of the separate sewers discharges into a storm-water drain not far from its outlet.

There are six sewer outlets, and it is estimated that there are about 700 persons connected with the sewers. All of the sewer outlets are carried out into the river, so that they discharge below the water at all times, and they are so situated as not to be objectionable. Sewage and wastes from five paper mills employing about 375 persons are discharged directly into the Housatonic River at Lee.

In Lee the river is joined by Goose Pond Stream, so called, on which there are two paper mills and a machine shop, sewage and wastes from which are discharged directly into the stream, and there are several privies situated directly over the stream.

The next town on the stream is Stockbridge, which is 18 miles below Pittsfield and 7 miles below Lee. This town had a population in 1900 of 2,081, and the main village is quite thoroughly sewered. The sewers were constructed in 1898 on the separate plan, and all of the sewage is purified upon filter beds and an irrigation area situated near the river below the village. About 125,000 gallons of sewage per day are treated at these works, and the effluent has no appreciable effect upon the character of the water of the river.

Great Barrington, situated about 11 miles below Stockbridge, had a population in 1900 of 5,854, included in two principal villages, both of which are upon the river. The upper village, known as Housatonic, has several sewers which were built originally for storm-water drains, but also receive sewage. The quantity of sewage in these drains is small and the outlets are unobjectionable. Sewage and wastes from two cotton mills employing about 500 persons, and a paper mill employing 300 persons, are discharged into the river at Housatonic.

The village of Great Barrington is thoroughly sewered, the sewage being discharged into the river through twelve outlets, all of which are beneath the surface of the water. None of the outlets were objectionable at the time they were examined.

Sewage and wastes from a cotton mill employing 120 persons, and the sewage from an instrument factory employing 250 persons, are discharged into the river at Great Barrington.

Notwithstanding the pollution which the river receives from the various sewer outlets and factories in the cities and towns below Pittsfield, the character of the water improves; and at Sheffield, the lowest point at which samples have been collected for analysis, the quality of the water is very much better than immediately below Pittsfield, though it is still somewhat objectionable in appearance.

The most serious sources of pollution are at Pittsfield. The sewage purification works, which were put in operation in the latter part of 1902, will improve the conditions considerably; but it will be necessary to remove the remainder of the sewage and the most of the manufacturing wastes, to render the stream unobjectionable.

A special examination of the Housatonic River was made Sept. 30 and Oct. 1, 1902, the results of which are given in the following table. At the time this examination was made, the flow of the river was much greater than the ordinary dry-weather flow.

SPECIAL EXAMINATION OF HOUSATONIC RIVER, SEPT. 30 AND OCT. 1, 1902.

[Parts per 100,000.]

SOURCE.	Free Ammonia.	Albuminoid Ammonia.	Chlorine.
East branch, above Dalton,	.0040	.0264	.14
East branch, above Pittsfield,	.0040	.0324	.14
East branch, near mouth,	.0048	.0324	.24
Onota Brook, at mouth,	.0008	.0368	.22
Pontoosuc Brook, at mouth,	.0024	.0260	.12
West branch, at mouth,	.0064	.0260	.23
South-west branch, near mouth,	.0008	.0176	.11
Housatonic, above Pittsfield filtration area,	.0064	.0280	.21
Housatonic, below Pittsfield filtration area,	.0112	.0300	.20
Housatonic, near outlet of Lenox mill pond,	.0124	.0212	.22
Housatonic, ½ mile below Lenox mill pond,	.0128	.0240	.21
Housatonic, 2 miles below Lenox mill pond,	.0120	.0252	.22

Regular examinations have been made of the three branches of the river, and of the main river below Pittsfield and at Stockbridge and Sheffield. The averages of the analyses from June to November, inclusive, for each year, are given in the tables which follow: —

CHEMICAL EXAMINATION OF WATER FROM THE HOUSATONIC RIVER AND ITS BRANCHES. — AVERAGES FOR SIX MONTHS, FROM JUNE TO NOVEMBER, INCLUSIVE.

East Branch, at Pittsfield.

[Parts per 100,000.]

YEAR.	Color.	RESIDUE ON EVAPORATION.		AMMONIA.				Chlorine.	NITROGEN AS		Oxygen Consumed.	Hardness.
		Total.	Loss on Ignition.	Free.	ALBUMINOID.				Nitrates.	Nitrites.		
					Total.	Dissolved	Suspended.					
1898, ...	.36	9.42	2.77	.0089	.0213	.0174	.0039	.16	.0140	.0004	.51	6.3
1899, ...	.32	10.37	2.40	.0081	.0328	.0269	.0059	.21	.0122	.0003	.60	6.5
1900, ...	.28	11.05	2.36	.0142	.0378	.0287	.0091	.27	.0112	.0006	.51	7.5
1901, ...	.31	9.62	3.24	.0171	.0311	.0200	.0111	.18	.0093	.0004	.58	7.0
1902, ...	.30	9.26	2.95	.0128	.0265	.0199	.0066	.16	.0100	.0005	.57	6.6

West Branch, at Pittsfield.

1898, ...	.14	9.12	1.69	.0037	.0189	.0132	.0057	.12	.0037	.0004	.22	6.7
1899, ...	.16	10.62	2.35	.0054	.0394	.0284	.0110	.29	.0024	.0002	.41	6.7
1900, ...	.15	9.25	1.65	.0044	.0334	.0194	.0140	.23	.0021	.0001	.31	5.5
1901, ...	.11	8.57	2.70	.0109	.0262	.0161	.0101	.19	.0027	.0002	.30	6.4
1902, ...	.11	9.00	2.40	.0020	.0282	.0161	.0121	.16	.0005	.0004	.37	6.1

South-west Branch, at Pittsfield.

1899, ...	.17	14.92	2.58	.0040	.0353	.0211	.0142	.16	.0108	.0004	.37	9.2
1900, ...	.14	14.87	2.15	.0192	.0335	.0229	.0106	.21	.0107	.0008	.35	10.2
1901, ...	.14	13.20	3.87	.0051	.0302	.0197	.0105	.16	.0096	.0004	.41	9.4
1902, ...	.11	12.30	3.09	.0057	.0224	.0136	.0088	.12	.0108	.0005	.37	8.7

Housatonic River, below Pittsfield.

1893, ...	.35	11.17	2.44	.0074	.0192	.0151	.0041	.18	.0162	.0022	.47	8.1
1894, ...	.35	12.97	2.47	.0208	.0194	.0169	.0025	.32	.0205	.0045	.40	9.5
1895, ...	.30	12.62	2.88	.0228	.0265	.0214	.0051	.31	.0154	.0070	.48	8.8
1896, ...	.27	12.22	2.07	.0224	.0184	.0154	.0030	.23	.0168	.0066	.35	9.5
1897, ...	.37	11.19	2.46	.0143	.0255	.0170	.0085	.18	.0185	.0007	.42	8.3
1898, ...	.28	10.29	2.43	.0171	.0283	.0168	.0115	.16	.0180	.0011	.41	7.3
1899, ...	.24	12.53	2.88	.0311	.0278	.0226	.0052	.32	.0117	.0028	.40	8.1
1900, ...	.27	12.69	2.52	.0592	.0303	.0234	.0069	.33	.0088	.0029	.46	8.2
1901, ...	.21	11.03	3.46	.0315	.0331	.0197	.0134	.25	.0085	.0025	.43	7.6
1902, ...	.19	10.63	3.32	.0133	.0245	.0163	.0082	.20	.0108	.0022	.42	7.3

CHEMICAL EXAMINATION OF WATER FROM THE HOUSATONIC RIVER AND ITS BRANCHES. — AVERAGES FOR SIX MONTHS, FROM JUNE TO NOVEMBER, INCLUSIVE — *Concluded.*

Housatonic River, below Stockbridge.

[Parts per 100,000.]

YEAR.	Color.	RESIDUE ON EVAPORATION.		AMMONIA.				Chlorine.	NITROGEN AS		Oxygen Consumed.	Hardness.
					ALBUMINOID.							
		Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		
1899, ...	.19	12.61	2.50	.0119	.0246	.0180	.0066	.29	.0102	.0010	.36	8.3
1900, ...	.16	13.31	2.67	.0195	.0260	.0205	.0055	.35	.0152	.0015	.39	9.6
1901, ...	.20	12.03	3.91	.0149	.0222	.0186	.0036	.26	.0158	.0019	.43	8.2
1902, ...	.24	11.39	3.35	.0121	.0188	.0150	.0038	.24	.0132	.0021	.41	7.5

Housatonic River, at Sheffield.

1899, ...	.16	12.96	2.81	.0094	.0249	.0219	.0030	.33	.0136	.0004	.35	8.7
1900, ...	.16	12.81	2.31	.0080	.0232	.0188	.0044	.29	.0170	.0005	.35	9.5
1901, ...	.20	11.96	3.51	.0060	.0196	.0173	.0023	.23	.0138	.0005	.38	7.7
1902, ...	.15	11.83	2.81	.0080	.0161	.0133	.0028	.21	.0117	.0007	.41	8.2

MERRIMACK RIVER.

The Merrimack River, the second largest stream in Massachusetts, rises in the central portion of New Hampshire, flows southerly through the State to the city of Lowell, in Massachusetts, thence easterly through the north-easterly section of Massachusetts, discharging into the sea at Newburyport. It is affected by the tides up to a point between Haverhill and Lawrence, 21 miles from its mouth.

The upper portion of the drainage area is very mountainous, but in the lower portions there are large areas of flat land, especially in that portion of the water-shed within Massachusetts. The water of the river is largely used for manufacturing purposes, and there are many storage reservoirs within the water-shed, which tend to equalize the flow of the stream.

Careful measurements of the quantity of water flowing in the Merrimack River at Lawrence have been made for a long period of years, and records are kept of the flow of two tributaries, the Sudbury and the South Branch of the Nashua River. Copies of these records for the year 1902 will be found on page 172 of this volume.

The principal portion of the water-shed of the river in Massachusetts is contained within the water-sheds of its three tributaries, — the Nashua River, which enters it in New Hampshire, the Concord River and the Shawsheen River. The first two of these rivers are described in other portions of this report.

The following tables give statistics with reference to the water-sheds and the populations upon the water-sheds at various places: —

LOCALITY.	Distance above Mouth (Miles).	Drainage Area (Square Miles).	Population on Drainage Area.	Population per Square Mile.	Estimated Population discharging Sewage or Sewage Effluent into River.
Merrimack River, at Lowell dam, . .	38	4,127	302,700	73	140,000
Merrimack River, at Lawrence dam, . .	26	4,664	485,500	104	255,000
Merrimack River, just below Haverhill, .	16	4,882	602,700	123	363,000
Merrimack River, at mouth, ...	0	4,995	634,900	127	383,000

PRINCIPAL CITIES AND TOWNS ON THE MERRIMACK RIVER AND ITS TRIBUTARIES.

CITY OR TOWN.	Population in 1900.	Stream on which located.	Distance above Mouth of Merrimack River.	Sewerage System.
Plymouth, N. H., ...	1,972	Pemigewasset, . .	125.6	-
Franklin, N. H., ...	5,846	Merrimack, . . .	100.9	-
Laconia, N. H., ...	8,042	Winnipiseogee, . .	112.4	-
Concord, N. H., ...	19,632	Merrimack, . . .	80.1	-
Pembroke, N. H., ...	3,183	Merrimack, . . .	72.4	-
Manchester, N. H., ...	56,987	Merrimack, . . .	62.0	General.
Milford, N. H., ...	3,739	Souhegan, . . .	63.4	-
Fitchburg, ...	31,531	North Branch, Nashua,	92.0	General.
Leominster, ...	12,392	North Branch, Nashua,	84.5	General.
Clinton, ...	13,667	South Branch, Nashua,	81.2	General.*
Ayer, ...	2,446	Nashua, . . .	70.2	None.
Pepperell, ...	3,701	Nashua, . . .	59.5	Few sewers.
Nashua, N. H., ...	23,898	Nashua, . . .	50.0	General.
Chelmsford, ...	3,984	Merrimack, . . .	41.5	None.
Westford, ...	2,624	Merrimack, . . .	46.0	None.
Lowell, ...	94,969	Merrimack, . . .	35.7	General.
Dracut, ...	3,253	Merrimack, . . .	37.2	Few sewers.
Westborough, ...	5,400	Sudbury, . . .	82.7	General.*
Northborough, ...	2,164	Assabet, . . .	74.0	None.
Marlborough, ...	13,609	Sudbury, . . .	79.0	General.*
Hudson, ...	5,454	Assabet, . . .	67.1	Partial.
Maynard, ...	3,142	Assabet, . . .	58.5	Partial.*

* Sewage purification works in use.

PRINCIPAL CITIES AND TOWNS ON THE MERRIMACK RIVER AND ITS TRIBUTARIES — *Concluded.*

CITY OR TOWN.	Population in 1900.	Stream on which located.	Distance above Mouth of Merrimack River.	Sewerage System.
Framingham,	11,302	Sudbury,	70.5	General.*
Natick,	9,488	Sudbury,	71.0	General.*
Concord,	5,652	Concord,	52.0	General.*
Billerica,	2,775	Concord,	42.3	Partial.*
Derry, N. H.,	3,583	Merrimack,	52.5	-
Lawrence,	62,559	Merrimack,	26.0	General.
Methuen,	7,512	Merrimack,	28.4	General.
Andover,	6,813	Shawsheen,	28.5	General.*
North Andover,	4,243	Merrimack,	24.5	Partial.
Haverhill,	37,175	Merrimack,	16.0	General.
Amesbury,	9,473	Merrimack,	4.0	Partial.
Newburyport,	14,478	Merrimack,	0.0	General.

* Sewage purification works in use.

There are several large cities on the river or its tributaries above the point where it enters Massachusetts, from which sewage is discharged directly into the river, and there are numerous factories which contribute sewage and manufactural wastes to the stream; so that when it reaches Massachusetts it is already much polluted, though the pollution has not thus far affected the appearance of the stream, or caused it to have a noticeable odor.

The first city in Massachusetts through which the river passes is Lowell, the populated section of which is situated on both sides of the river. A small tributary, Stony Brook, flows through Westford and Chelmsford and enters the river from the south just above the city, and Beaver Brook enters it from the north below the dam.

The principal sources of pollution on Stony Brook are six woolen mills, employing over 700 persons and scouring about 70,000 pounds of wool per day, all the sewage and wastes from which are discharged into the stream. In addition there are several smaller factories, employing altogether about 700 persons, and discharging sewage but no wastes into the stream; and there is a small population in Chelmsford which is connected with sewers discharging into the brook. This stream is very badly polluted.

On the northerly side of the river, in the town of Dracut, on Beaver Brook, there are two large woolen mills employing 1,100 persons, sewage from which, together with water used for scouring a small quantity of wool and that used in washing and dyeing, is discharged into the brook. The sink wastes from a considerable population and some sewage from private houses are also discharged into Beaver Brook.

The Concord River, having a water-shed of 402 square miles, enters the Merrimack River from the south in the easterly part of the city of Lowell. This river and the sources of pollution upon it are described under the "Concord River."

The city of Lowell had in 1900 a population of 94,969. The city is thoroughly sewered, there being a little over 84 miles of sewers at the present time; and all of the sewers are built on the combined plan, receiving both sewage and storm water. All of the principal sewer outlets discharge directly into the Merrimack or Concord rivers. In a few cases the outlets of the sewers are located beneath the ordinary level of the water in the river, where the outlet is at all times covered with water, and such outlets are not noticeable in the neighborhood. Many of the outlets are located at the edge of the river, and some of them when the water is low discharge upon the ground some distance back from the water, creating very offensive conditions.

The following is a general description of the outlets of Lowell sewers: —

At the westerly end of the city three small sewers discharge at the southerly bank of the river above the dam, where there is always a considerable depth of water. When examined, the conditions about these outlets were not objectionable, though all of the sewage passes into the main canal, from which water is taken for washing and various other purposes in the mills.

The sewage of the Pawtucketville district on the northerly side of the river is collected at two principal outlets, one of which discharges in the rocky bed of the Merrimack River below the dam a short distance below the Pawtucket bridge, and the other into Beaver Brook at the point where that stream joins the Merrimack River.

The sewage from the westerly outlet collects among the rocks in its neighborhood when little or no water is running over the dam, and causes a serious nuisance. There is a considerable odor of sewage in the immediate vicinity of the outlet at Beaver Brook, but, as there are no dwelling houses within a long distance of this outlet, it does not appear to be seriously objectionable at the present time.

The sewage of the Centralville district in the north-easterly part of the city north of the Merrimack River is discharged into the river at eight outlets, the most important of which is at the end of West Street, where the sewage discharges at the bank of the river near the line of ordinary high water, and in summer, when the water is low, runs over the exposed bed of the river nearly 200 feet to the water. The sewage spreads over a large area, and collects among the weeds, bushes and rocks between the outlet and the water, causing a very serious nuisance.

The next outlet down stream is at Fulton Street, where a similar nuisance exists, though the quantity of sewage discharged at this place is small; and a short distance further down stream there is a similar outlet, having a somewhat larger flow of sewage, about which the conditions are very objectionable.

Two of the remaining outlets in this section were also objectionable on account of deposits of sewage about them; but the other outlets on this side of the river discharge below the level of low water in the river, and were not objectionable.

The principal outlet for sewage on the southerly side of the river is at the Aiken Street bridge, where the sewage flows into the stream through the middle of the bridge abutment at the edge of the river. A strong odor of sewage was noticeable on the highway and on the bridge in the neighborhood of the outlet, and the water of the river was very noticeably polluted for a considerable distance.

A small outlet a short distance above Aiken Street discharges below the Moody Street bridge into an open ditch, through which it flows about 150 feet to the edge of the river. The odor in the neighborhood of this ditch is very offensive.

Between the outlet at Aiken Street and Central bridge there are two outlets at the edge of the river, which in this vicinity is walled. There are two main sewer outlets and several minor outlets into the Concord River near its mouth. One of the main outlets discharges where there is an overflow from the canal into the river. At times when no water is wasting from the canal, the sewage collects in a pool about this outlet, and is very offensive to the operatives of the mills in the neighborhood. Another very large sewer enters the Concord River near its junction with the Merrimack at a place where the river is walled. The sewage from this outlet was discharging into a considerable body of water, and an odor of sewage was noticeable in the neighborhood, but no deposits were visible.

There are three comparatively small outlets into the Merrimack River on the southerly side of the city below the Concord River, two of which discharge above the level of high water, and the odor about them is offensive. The third outlet discharges at the level of the water, and does not appear to be objectionable.

In Lowell there are seven cotton mills, employing 16,000 persons, sewage from which is discharged into the river or into the canals, together with enormous quantities of spent dyes. In one woolen mill 2,300 persons are employed, and about 100,000 pounds of wool are scoured each week. All of the sewage and wastes from these factories go into the stream or into the canals. There is also a machine shop employing 1,300 persons, which discharges sewage and acid wastes into the river.

Below Lowell the river flows for a distance of about 8 miles through a territory which is sparsely populated to the city of Lawrence. The river in this portion of its course is used very largely as a pleasure resort, and the water supply of the city of Lawrence is taken from the river just above the city, the water being purified by sand filtration.

The city of Lawrence, which in 1900 had a population of 62,559, is situated on both sides of the Merrimack River, about 26 miles above its mouth, the larger portion of the city being on the northerly side of the river.

The town of Methuen adjoins Lawrence, and the sewage from the town enters the Lawrence sewers; while the wastes from the principal factories enter Spicket River, which flows through Lawrence and discharges into the Merrimack River in the lower portion of that city.

The sewerage system of Lawrence is constructed on the combined plan, receiving both sewage and storm water, and some of the sewers also receive wastes from factories. All of the sewers discharge directly into the Merrimack River or into the Spicket River, and there are a few private outlets from the mills and other buildings near the bank of the river.

There are three small sewer outlets on the northerly side of the river above the dam. At two of these the sewer discharges into a ditch at a considerable distance from the shore and very offensive conditions are produced. At the third, the outlet is below the ordinary water level of the river.

Just below the dam a large sewer discharges at the easterly end of the Broadway bridge over the Merrimack River. At times when little or no water is flowing over the dam the sewage from this outlet collects in a large pool under the bridge, and at such times the odor is very offensive to persons passing over the bridge. The conditions about this outlet could be greatly improved if the sewer should be extended further out into the river and further down stream.

In the rear of the Upper Pacific mills a considerable quantity of sewage and manufacturing waste is discharged at some distance above the water level and 100 feet from the edge of the stream. The ditch through which the sewage passes from the sewer to the stream was obstructed and much sewage had deposited.

The Lawrence Street sewer discharges through a wall at the edge of the river bank in the rear of the Lower Pacific mills, at about the ordinary water level. The bottom of the river in this region is generally covered with water, and, while an odor of sewage was noticeable in the neighborhood of the outlet, the outlet did not appear to be seriously objectionable when examined, although the flow of the river at the time of the examination was not as low as it is during much of the year.

Another sewer discharges into the river through the Washington mills. This sewer discharges about 50 feet from the river and the odor of sewage was quite noticeable in its vicinity.

At the Spicket River at Garden Street there is an outlet for a sewer which serves a large section of the city and also a large portion of the town of Methuen. The outlet is located under the westerly end of the Garden Street bridge and the conditions about it are at times very objectionable and the river below is greatly polluted.

An outlet at Marston Street is located in a ravine about 150 feet back from the river, and slightly above its level at ordinary water. The sewage flows through a channel obstructed by brush and other débris for a distance of from 75 to 100 feet to the river. Sewage deposits in the ravine, and the odor at this outlet is very foul. Gas wastes were discharged just above the outlet at the time it was examined, and the mingled gas wastes and sewage caused a very objectionable nuisance.

On the southerly side of the river one of the principal outlets is at South Broadway, where a large quantity of sewage is discharged under the middle of the abutment of the Broadway bridge over the Merrimack River. The sewage discolors the water for a considerable distance from the outlet, but no objectionable odors were noticed at the time the outlet was examined, when there was a large flow of water over the dam.

A sewer discharges through the river wall in the rear of the Munroe Paper Company into a considerable body of water and does not produce objectionable conditions.

At Parker Street a sewer discharges through an iron pipe into a large pool on the south side of the river, about 100 feet from the water. At times of ordinary summer flow in the river a stream of sewage from this outlet flows up stream in the exposed bed of the river a distance of 100 feet or more, and then flows out into the river. The quantity of sewage discharged at this outlet is large, and after entering the river the sewage flows along the shore for from 300 to 400 feet, and the conditions about the outlet are very offensive in the summer season.

The Osgood Street outlet is located 75 feet back from the bank of the river at its ordinary stage, and the sewage discharges through a stone abutment, the bottom of the sewer being about 3 feet above the ordinary level of the water. The sewage flows through a channel worn in the river silt, and obstructed by brush and weeds, which retain much of the solid matter. After entering the river the sewage follows along the shore for a considerable distance, and the conditions about the outlet are foul. There are no dwelling houses in the immediate vicinity of this outlet.

In addition to the main outlets of sewers described above, there are several storm overflows into the Spicket River, through which mingled sewage and storm water are discharged into the stream at times of storm.

Nearly all of the factories in Lawrence and Methuen discharge sewage through private sewers directly into the river, together with whatever manufacturing wastes are produced, but some of the smaller factories are connected with the city sewers. About 16,000 persons are employed in the various factories.

The principal manufacturing wastes which tend to pollute the river come from three paper mills, three cotton mills, two bleacheries, three woolen mills and a wool-scouring mill. The wastes from scouring about 1,300,000 pounds of wool each week, containing enormous quantities of very foul matter, are discharged into the river.

On the southerly side of the river, below Lawrence, the Merrimack River is joined by the Shawsheen River, which has a water-shed of 75 square miles. The town of North Andover, population in 1900, 4,243, is situated on this stream, but the sewage of the town is discharged principally into Cochickewick Brook, near its junction with the Merrimack River.

The main sewer outlet originally discharged into the Merrimack River, immediately below the entrance of the brook, but the pipe which conveyed the sewage across the brook has been broken, so that at the present time the sewage is discharged into Cochickewick Brook, about 100 feet above the Merrimack River. The effect of the sewage on the water of the brook was very noticeable at the time it was examined, but the sewage is discharged into a large body of water, and there appear to be no deposits in its vicinity. The other outlet discharges into the Shawsheen River at the highway bridge near its mouth, the sewage flowing out of a pipe several feet above the surface of the water. The conditions about this outlet are not seriously objectionable.

In North Andover there are four factories, employing together about 1,100 persons, all of the sewage from which is discharged into the streams. Three of the four factories are woolen mills, in which wool is scoured, the amount scoured being about 14,500 pounds per day. At one of these factories, in which 3,000 pounds of wool are scoured daily, the wastes are discharged into settling tanks, and the solid matter which accumulates in the bottom is removed by farmers and used for fertilizer; the remaining portion of the wastes is discharged into the stream.

About 2.5 miles above its mouth the Shawsheen River receives the effluent from the sewage purification works of the town of Andover, together with a small amount of unpurified sewage. The town of Andover had in 1900 a population of 6,813; and a sewerage system was constructed in 1899, the sewage being purified on sand filter beds near the Shawsheen River. The quantity of sewage treated at these works amounts to about 150,000 gallons per day. A small portion of the sewage from low sections of the town is collected at two small pumping stations, from which it is pumped into the sewers leading to the filter beds; but during a portion of the time these pumps are not operated, and the sewage is discharged into the river.

There are three factories in Andover from which sewage and wastes are discharged into the stream. The number of persons employed in these factories is about 800, and the principal wastes are those from scouring about 30,000 pounds of wool per week and from washing and dyeing cloth.

About 5.5 miles above Andover the river is joined by Strongwater

Brook, which receives the sewage from the State Hospital at Tewksbury, which has a population of about 1,400. A part of this sewage is discharged upon land, but a large portion finds its way in an unpurified state directly into the brook.

Below the Shawsheen River the Merrimack River flows rapidly for a distance of about 6 miles to a point where the water of the river is affected by the tides.

The city of Haverhill is situated 10 miles below Lawrence and 16 miles from the mouth of the river. The principal portion of the city is on the northerly side of the river, but that portion known as Bradford is on the southerly side.

The city is provided with a regular system of sewers built upon the combined plan, with the exception of the sewers in a small area in the northerly part of the city, for which the separate system has been adopted. The sewage is all discharged into the Merrimack River through thirty-six outlets, thirty-one of which are on the northerly side of the river, and the remaining five on the southerly side in the Bradford district.

Besides the outlets of the city sewers, there are numerous outlets of private sewers from buildings along the banks of the river.

The height of the water in the river is affected by the tides, which have an ordinary range of 4 or 5 feet opposite the city. At times of very low flow in the river the current is up stream during a portion of the incoming tide.

The following is a brief description of the conditions about the principal outlets examined, taking them in order going down stream on the northerly side of the river.

The upper principal outlet is at Florence Street. The sewer at this place discharges into a ravine above the level of the ordinary stage of the river, and 50 feet or more from the channel at low water. The ravine through which the sewage flows contains brush and rubbish of various sorts, among which much matter from the sewage has collected, and from which a very offensive odor arises. There are no dwelling houses, however, in the immediate vicinity of this outlet.

Similar conditions exist at the Vilas Street and Beach Street outlets, the next two outlets in order going down stream.

At Ayer Street the sewage discharges at a high wall at the edge of the river near the level of low water; and, while the water is slightly polluted along the edge of the river, the odor from this outlet was not seriously objectionable when examined.

Near Ford Street there is an outlet at the edge of low water, where the conditions are similar to those at Ayer Street, but the bank of the river is not walled at this place.

At Washington Avenue, just above the Boston & Maine Railroad bridge, sewage is discharged at the edge of the water at low tide, and collects in an eddy just above the bridge, where there is a foul deposit. The conditions about this outlet are objectionable.

At Essex and Emerson streets there are large sewers discharging through a wall at the bank of the river, which are chiefly objectionable on account of the odor of sewage in the neighborhood.

The outlets at West, Howe, Tucker, Fleet, Main and State streets all discharge at the edge of the river, which is here bordered by a wall, and the sewage is discharged into a considerable depth of water at all stages of the tide. An odor of sewage is noticeable about these outlets, but excepting at West Street there were no considerable deposits.

At Moore and Kent streets the sewage discharges at the edge of the river at low water, and the conditions about these outlets were objectionable on account of the deposits of sewage and an offensive odor.

All of the remaining outlets on the northerly side of the river below Kent Street, with one exception, discharge near the high-water bank of the river, from which the sewage flows across the exposed bottom of the river for distances of from 20 to 40 feet to the water at the time of low tide. At these outlets there were deposits of solid matter from the sewage, covering a considerable area of the exposed river bottom between high and low water, and the conditions were very offensive at low tide. The single exception is the outlet at Chestnut and School streets, which discharges through a wall under the water, and is not noticeably objectionable.

On the Bradford side of the river the principal outlets are at Bradford Avenue, Prospect, Summer, Main and Ferry streets. At all of these outlets objectionable conditions were found, and some of them were extremely offensive. At Ferry Street the sewage is discharged at a point 75 feet back from the edge of the river into a channel obstructed by débris of various kinds, which holds the sewage back in pools. There is a large flow of sewage from this outlet, but there are no dwelling houses in its immediate neighborhood.

The very offensive conditions about most of the Haverhill sewer outlets could be removed by extending the sewers under the stream so as to discharge the dry-weather flow of sewage at a considerable distance from the shore, where it would not be liable to return and cause deposits of sewage to form on the banks and bottom of the stream exposed at low water.

In addition to the objectionable conditions caused by the main outlets of sewers in the city of Haverhill, there are storm overflows from some of the principal sewers which discharge into Little River in its course through the thickly settled portions of the city. This river also receives much pollution from manufacturing wastes and refuse from the factories, and is at times a very objectionable nuisance in the lower part of its course.

There is a great number of small factories in the city of Haverhill, most of which discharge sewage directly into the Merrimack River or into Little

River, and some of them discharge considerable quantities of manufacturing wastes.

The principal factories discharging manufacturing wastes into Little River are a woolen factory, in which 15,000 pounds of wool are scoured weekly, a tannery and a gas works. The wastes from these three factories have a very serious effect upon the character of the river, and give it a very objectionable appearance and odor.

On the Merrimack River are a brewery, a paper mill and two hat factories, from all of which considerable quantities of polluting wastes are discharged into the river.

Below Haverhill the river is a tidal stream. About 4 miles above its mouth it receives from the north the flow of the Powow River, on which is situated the town of Amesbury, which had in 1900 a population of 9,473. This town is not provided with a regular sewerage system, although many of the buildings in the centre of the village are connected with sewers or drains, which discharge both sewage and storm water directly into the river. These sewer outlets are very objectionable, and they are located in the midst of a large population.

The principal factories in Amesbury are carriage factories, which produce no liquid wastes. There is a large cotton factory employing from 700 to 800 persons, situated in the centre of the village, where no liquid wastes are produced. All of the sewage from the various factories is discharged directly into the river. The number of persons employed in these mills is about 1,300.

Below Powow River the Merrimack River flows for a distance of 3 miles to the city of Newburyport, which is situated near its mouth. The sewer outlets from this city are described in Part I of this report.

Samples of water collected from the river above Lowell and above Lawrence have been analyzed for a long period of years, and the average results of these analyses for the drier portion of each year are given in the tables which follow. A special examination of the river has also been made, the results of which are presented.

SPECIAL EXAMINATION OF MERRIMACK RIVER, SEPT. 23, 1902.

[Parts per 100,000.]

SOURCE.	Free Ammonia.	Albuminoid Ammonia.	Chlorine.
Merrimack River, above Lowell, ...	.0097	.0137	.18
Merrimack River, below Lowell, ...	.0092	.0278	.34
Merrimack River, above Lawrence, ...	.0112	.0222	.28
Merrimack River, below Lawrence, ...	.0030	.0572	.33
Merrimack River, above Haverhill, ...	.0102	.0316	.31
Merrimack River, below Haverhill, ...	.0152	.0268	.30

CHEMICAL EXAMINATION OF WATER FROM THE MERRIMACK RIVER. — AVERAGES FOR SIX MONTHS, FROM JUNE TO NOVEMBER, INCLUSIVE.

Merrimack River, above Lowell.

[Parts per 100,000.]

YEAR.	Color.	RESIDUE ON EVAPORATION.		AMMONIA.				Chlorine.	NITROGEN AS		Oxygen Consumed.	Hardness.
					ALBUMINOID.							
		Total.	Loss on Ignition.	Free.	Total.	Dis-solved.	Sus-pended.		Nitrates.	Nitrites.		
1887,	.45	4.08	1.10	.0024	.0156	–	–	.17	.0078	–	–	–
1888,	.32	3.47	1.01	.0014	.0161	.0137	.0024	.16	.0082	.0002	–	–
1889,	.37	–	–	.0028	.0166	.0143	.0023	.17	.0067	.0001	–	–
1890,	.34	3.85	1.58	.0025	.0148	.0123	.0025	.14	.0106	.0002	–	1.4
1891,	.27	3.73	1.47	.0029	.0147	.0111	.0036	.17	.0080	.0002	–	1.4
1892,	.39	3.75	1.37	.0028	.0139	.0106	.0033	.15	.0097	.0002	–	1.6
1893,	.25	3.47	1.13	.0028	.0141	.0110	.0031	.17	.0072	.0001	.38	1.1
1894,	.29	3.86	1.32	.0037	.0140	.0114	.0026	.19	.0042	.0001	.36	1.2
1895,	.43	3.97	1.61	.0019	.0197	.0151	.0046	.24	.0054	.0001	.55	1.2
1896,	.44	3.85	1.41	.0049	.0181	.0149	.0032	.18	.0053	.0002	.66	1.0
1897,	.54	3.62	1.68	.0030	.0181	.0148	.0033	.16	.0077	.0001	.52	0.9
1898,	.39	3.93	1.74	.0032	.0197	.0171	.0026	.19	.0047	.0001	.51	1.0
1899,	.20	3.88	1.45	.0050	.0205	.0166	.0039	.22	.0055	.0002	.38	1.2
1900,	.23	3.72	1.21	.0068	.0215	.0158	.0057	.23	.0038	.0002	.44	1.3
1901,	.38	4.32	1.98	.0060	.0208	.0172	.0036	.20	.0042	.0002	.69	1.2
1902,	.38	3.81	1.59	.0056	.0163	.0142	.0021	.17	.0043	.0001	.64	0.9

Merrimack River, above Lawrence.

1887,	.47	4.82	1.24	.0027	.0211	–	–	.22	.0097	–	–	–
1888,	.32	3.64	1.13	.0029	.0197	.0153	.0044	.18	.0074	.0003	–	–
1889,	.35	–	–	.0047	.0212	.0176	.0036	.20	.0053	.0002	–	–
1890,	.37	4.27	1.56	.0061	.0187	.0148	.0039	.19	.0068	.0002	–	1.6
1891,	.21	4.06	1.37	.0066	.0179	.0138	.0041	.21	.0090	.0002	–	1.4
1892,	.46	4.25	1.50	.0054	.0186	.0155	.0031	.19	.0087	.0002	–	1.5
1893,	.40	4.25	1.62	.0084	.0172	.0138	.0034	.23	.0057	.0003	.52	1.3
1894,	.32	3.82	1.35	.0086	.0174	.0142	.0032	.25	.0043	.0001	.40	1.3
1895,	.52	4.45	1.97	.0068	.0251	.0194	.0057	.30	.0067	.0003	.60	1.5
1896,	.46	4.24	1.70	.0100	.0224	.0181	.0043	.25	.0067	.0005	.57	1.3
1897,	.58	4.06	1.67	.0061	.0222	.0190	.0032	.21	.0053	.0002	.53	1.0
1898,	.44	4.46	1.87	.0076	.0262	.0208	.0054	.25	.0050	.0005	.59	1.3
1899,	.24	4.42	1.57	.0138	.0277	.0207	.0070	.32	.0052	.0004	.43	1.3
1900,	.27	4.22	1.35	.0126	.0249	.0190	.0059	.32	.0050	.0003	.46	1.3
1901,	.44	4.73	1.90	.0100	.0280	.0205	.0075	.28	.0070	.0006	.65	1.5
1902,	.42	4.40	1.85	.0110	.0231	.0180	.0051	.26	.0038	.0003	.65	1.1

Merrimack River, above Haverhill.

1887,	.43	5.24	1.32	.0031	.0220	–	–	.21	.0083	–	–	–
1888,	.38	3.96	1.19	.0013	.0209	.0163	.0046	.20	.0097	.0003	–	–
1899,	.29	5.56	1.87	.0148	.0368	.0260	.0108	.38	.0060	.0006	.58	1.6
1900,	.30	4.94	1.43	.0210	.0324	.0235	.0089	.41	.0052	.0007	.65	1.4
1901,	.44	5.27	2.24	.0133	.0330	.0222	.0108	.29	.0058	.0006	.65	1.5
1902,	.44	4.47	1.82	.0100	.0279	.0199	.0080	.27	.0050	.0004	.80	1.3

Merrimack River, below Haverhill.

1899,	.30	5.69	1.98	.0227	.0381	.0263	.0118	.38	.0060	.0006	.58	1.6
1900,	.32	5.03	1.52	.0311	.0335	.0246	.0089	.42	.0056	.0010	.57	1.2
1901,	.46	5.37	2.27	.0140	.0348	.0237	.0111	.30	.0050	.0006	.74	1.4
1902,	.42	4.77	1.82	.0226	.0333	.0223	.0110	.32	.0057	.0004	.72	1.4

MILLER'S RIVER.

The Miller's River is a tributary of the Connecticut from the east, draining a portion of New Hampshire and the northerly section of Massachusetts. The drainage area of the river is generally hilly, but there are considerable areas of comparatively flat land, and there are many lakes and ponds used for storage purposes.

The following tables give data relating to the drainage areas and the population on them at various places: —

LOCALITY.	Distance above Mouth (Miles).	Drainage Area (Square Miles).	Population on Drainage Area.	Population per Square Mile.	Estimated Population discharging Sewage or Sewage Effluent into River.
Miller's River, below Winchendon,	34.1	55.6	4,500	81	3,000
Otter River, below Gardner,	37.5	22.0	10,300	468	8,000
Otter River, at mouth,	29.3	61.9	14,600	236	8,600
Miller's River, below Otter River,	29.3	174.9	20,700	118	11,600
Miller's River, below Athol,	18.6	282.2	29,400	104	16,700
Miller's River, below Orange,	13.1	321.7	34,400	107	19,700
Miller's River, at mouth,	0	390.0	37,200	95	20,800

TOWNS, CONSIDERABLE PORTIONS OF WHICH ARE WITHIN THE WATER-SHED OF MILLER'S RIVER.

TOWN.	Population in 1900.	Sewerage System.	Estimated Population discharging Sewage or Sewage Effluent into River.	Manufactories discharging Wastes into River.
Jaffrey, N. H.,	1,891	-	-	- -
Fitzwilliam, N. H.,	987	-	-	- -
Rindge, N. H.,	855	-	-	- -
Ashburnham,	1,882	Few sewers.	0	None.
Winchendon,	5,001	Partial.	3,000	Two cotton mills, one leather factory, one foundry.
Gardner,	10,813	General.*	8,000	One chair factory.
Templeton,	3,489	None.	600	One chair factory, one asbestos factory, one leather factory, one woolen mill, one stove factory.
Phillipston,	441	None.	0	None.
Royalston,	958	None.	100	One woolen mill.
Athol,	7,061	General.	5,000	One woolen mill, one machine shop, one thread mill, one straw factory, one satinet mill.
Orange,	5,520	General.	3,000	Two satinet mills, one machine shop.
Warwick,	619	None.	0	None.
Wendell,	492	None.	100	One paper mill.
Erving,	973	Partial.	500	One paper mill, one machine shop.
Montague,	6,150	Partial.	500	None.

* Sewage purification works in use.

The first sources of pollution of the river in Massachusetts are at Winchendon, where the sewage from thirteen factories, employing about 1,200 persons, is discharged directly into the river, together with manufacturing wastes from cotton mills and various other factories. The quantity of manufacturing wastes from these mills, with the exception of the dye wastes from the cotton mills, is quite small.

There is no regular system of sewerage in the town of Winchendon, but a large number of houses in the thickly populated sections of the town discharge sewage through private sewers into the brooks which are tributary to the river.

About 6 miles below Winchendon the river is joined by the Otter River, on which are the town of Gardner and the villages of Otter River and Baldwinville.

The town of Gardner had in 1900 a population of 10,813, and is provided with a general system of sewers. A portion of the sewage is conveyed to filter beds located on Pond Brook, a tributary of Otter River, where it is discharged on sand filter beds. The quantity of sewage received at these filter beds amounts ordinarily to about 250,000 gallons per day; but the filter beds are of insufficient capacity to provide for the purification of all of the sewage, and at times, especially during the winter and spring months when the quantity of sewage greatly exceeds the amount indicated above, a large portion of the sewage overflows from the filter beds directly into the brook without purification. Another portion of the sewage of Gardner is conveyed to filter beds located near Otter River, about 2 miles below Pond Brook. At this place the sewage is first passed through coke strainers and then through sand filters, and all of the sewage received at the beds is thoroughly purified. The quantity of sewage treated at this place amounts ordinarily to about 300,000 gallons per day. There are no factories in Gardner which contribute any considerable quantity of manufacturing wastes to the river.

At the village of Otter River, 6 miles below Gardner, there are three small factories employing together about 65 persons, the sewage from which, together with a very small quantity of manufacturing waste, is discharged into the river.

At Baldwinville in the town of Templeton, 1.75 miles below Otter River, there are five mills employing about 350 persons, which discharge sewage directly into the stream. These factories do not produce any considerable quantity of manufacturing waste. In this village a small quantity of sewage is discharged through private sewers into the river, and the river receives the sewage more or less directly from a hospital which has a population of about 150.

At South Royalston, 3 miles below the entrance of Otter River, sewage and manufacturing wastes from a woolen mill employing about 115 persons, together with dye wastes and water used for washing, are discharged into Miller's River.

The town of Athol is situated 7.25 miles below Royalston, and about 18.5 miles from the mouth of the river. The town is provided with a general system of sewerage, the sewage being discharged at various outlets into Miller's River and into Mill Creek, one of the tributaries of Miller's River from the south. The principal outlets are at the lower end of the village, discharging well out into the river beneath the surface of the water. These outlets are said to be objectionable at times when the water is held back by the dams above.

The principal factories in the town from which manufacturing wastes are discharged are a woolen mill, a silk mill and a hat factory. From each of these places a large quantity of objectionable waste is discharged into the river.

Just below the village of Athol the river receives the flow of Tully Brook from the north, on which is located a satinet mill, employing 30 persons, sewage and wastes from which are discharged into the stream.

The town of Orange is 5.5 miles below Athol. This town had a population in 1900 of 5,520, and is provided with a general system of sewerage, the sewage being discharged into the river through two outlets. The upper outlet is on the southerly side of the river, just below the works of the New Home Sewing Machine Company. This outlet discharges at the edge of the water at a considerable distance from any buildings, and no objectionable conditions are produced. The lower outlet is on the northerly side of the river at the railroad bridge below the village of Orange. In the vicinity of this outlet there are deposits of material from the sewage, and the conditions around the outlet are objectionable, but there is no population within a considerable distance of the outlet or of the river immediately below the outlet.

There are several factories in Orange employing a large number of persons, the sewage from which is all discharged either into the sewers or directly into the river. No considerable quantities of manufacturing wastes are produced at these factories.

Below Orange the river receives sewage from about 100 persons employed in small factories, from which no manufacturing wastes are discharged into the river.

In the town of Wendell, about 3 miles below Orange and 10 miles from the mouth of the river, there are three factories, employing about 87 persons, one of which is a paper mill, from which large quantities of polluting wastes are discharged.

At the village of Miller's Falls, part of which is in the town of Montague and part in the town of Erving, the river receives sewage from a considerable population. The village has no general system of sewerage, but there are various storm-water drains and private sewers discharging into the river. One of the outlets from Montague is very objectionable on account of the deposits of sewage in its vicinity, and a bad local nuisance is created. There are two factories at this place, one of which is a paper mill employing 60 persons, and discharging large quantities of waste into the river. The other is a tool factory, from which considerable quantities of acid wastes and the sewage of 350 persons are discharged.

Miller's River enters the Connecticut River about 4 miles above the village of Turner's Falls.

The stream above Athol is not badly polluted except in the immediate vicinity of the sources of pollution. Below Athol the water is very badly polluted by sewage and manufacturing wastes, and the effect of this pollution, together with the added pollution received at Orange, is noticeable for a considerable distance below the latter town. At the mouth of the river, however, the water is not badly polluted.

A special examination of the Miller's River has been made, the results of which are given in the following tables, together with the results of the examination of regular samples at various places during the dry months of several years: —

SPECIAL EXAMINATION OF MILLER'S RIVER, AUG. 25 AND 26, 1902.

[Parts per 100,000.]

SOURCE.	DAY SAMPLE.			NIGHT SAMPLE.		
	Free Ammonia.	Albuminoid Ammonia.	Chlorine.	Free Ammonia.	Albuminoid Ammonia.	Chlorine.
Miller's River, above Athol,	.0032	.0300	.14	.0048	.0292	.11
Mill Creek, near mouth,	.0064	.0304	.15	.0108	.0232	.19
Tully Brook, near mouth,	.0030	.0226	.07	–	–	–
Miller's River, below Athol, above sewer outlets,	.0028	.0288	.11	.0020	.0264	.10
Main sewer outlet,	.2600	.2000	1.65	.0360	.0460	.80
Miller's River, 2 miles below sewer outlet,	.0080	.0292	.14	.0032	.0260	.11
Miller's River, ¾ mile above dam at Orange,	.0072	.0280	.12	.0048	.0324	.12
Miller's River, at dam at Orange,	–	–	–	.0036	.0244	.13
South side sewer outlet, Orange,	.8100	.2700	1.90	.1500	.0530	1.03
Miller's River, below south side sewer outlet,	.0064	.0284	.11	–	–	–
North side sewer outlet, Orange,	1.7100	.5800	3.75	2.3200	.1200	2.40
Miller's River, just below north side sewer outlet,	–	–	–	.0080	.0328	.16
Miller's River, 1¼ miles below north side sewer outlet,	.0064	.0284	.11	–	–	–

Flow of sewage from north side sewer in Orange,	30,000 gallons per day.
Flow of sewage from south side sewer in Orange,	255,000 gallons per day.
Flow of river at Athol,	284 cubic feet per second.

Chemical Examination of Water from Miller's River. — Averages for Six Months, from June to November, inclusive.

Above Athol.

[Parts per 100,000.]

Year.	Color.	Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
					Albuminoid.							
		Total.	Loss on Ignition.	Free.	Total.	Dis-solved.	Sus-pended.		Nitrates.	Nitrites.		
1899, ...	1.00	4.60	2.13	.0051	.0296	.0256	.0040	.24	.0013	.0001	.99	1.0
1900, ...	.74	5.38	1.89	.0040	.0436	.0268	.0168	.17	.0074	.0001	.97	1.2
1901, ...	1.00	4.60	2.50	.0068	.0335	.0275	.0060	.22	.0040	.0001	1.08	.8

Above Orange.

1902, ...	1.00	4.32	2.26	.0045	.0291	.0244	.0047	.20	.0058	.0001	1.09	.8

Below Orange.

1898, ...	.88	4.10	2.21	.0141	.0278	.0238	.0040	.17	.0016	.0002	.96	.7
1900, ...	.74	4.44	1.89	.0058	.0297	.0248	.0049	.25	.0038	.0001	.92	.8
1901, ...	.88	4.10	2.13	.0067	.0300	.0246	.0054	.20	.0042	.0002	.97	1.1
1902, ...	.95	4.12	2.09	.0046	.0281	.0227	.0054	.20	.0038	.0001	1.06	.8

NASHUA RIVER.

The Nashua River is formed by the junction of the North and South branches at Lancaster. From Lancaster the river flows in a north-easterly direction into the State of New Hampshire, and joins the Merrimack River at Nashua in that State about 9 miles from the Massachusetts boundary.

The water of the South Branch of the Nashua River, about 5 miles above the junction of the two branches, is taken for the water supply of the metropolitan district; and during dry weather a large portion of the flow of this portion of the water-shed, which amounts to 118.23 square miles, is diverted from the stream.

The following tables give statistics relating to the drainage areas and the populations upon them at various places: —

Locality.	Distance above Mouth (Miles).	Drainage Area (Square Miles).	Population on Drainage Area.	Population per Square Mile.	Estimated Population discharging Sewage or Sewage Effluent into River.
North Branch, above Fitchburg, ...	47.4	55.2	4,900	89	500
North Branch, below Fitchburg, ...	43.3	62.1	27,800	448	28,500
North Branch, above Monoosnock Brook, .	39.8	83.1	36,600	441	29,000
Monoosnock Brook, at mouth, ...	39.8	11.5	6,600	574	7,000
North Branch, at mouth, ...	31.3	129.6	47,900	370	37,000
South Branch, at metropolitan water works dam.	36.2	118.2	7,400	63	0
South Branch, at mouth, ...	31.3	131.0	21,400	163	11,000
Total, North and South branches, . .	31.3	260.6	69,300	266	48,000
Nashua River, at State line, ...	7.4	508.0	85,500	168	49,600

CITIES AND TOWNS, CONSIDERABLE PORTIONS OF WHICH ARE WITHIN THE WATER-SHED OF THE NASHUA RIVER.

CITY OR TOWN.	Population in 1900.	Sewerage System.	Estimated Population discharging Sewage or Sewage Effluent into River.	Manufactories discharging Wastes into River.
Princeton, ...	975	None.	0	None.
Sterling, ...	1,420	None.	0	None.
Holden, ...	2,464	None.	0	None.
Boylston, ...	1,364	None.	0	None.
West Boylston, . .	2,314	None.	0	None.
Clinton, ...	13,667	General.*	11,000	One cotton mill, two worsted mills.
Ashburnham, . .	1,882	Few sewers.	500	None.
Westminster, . .	1,327	None.	0	None.
Fitchburg, ...	31,531	General.	28,000	Thirteen paper mills, one cotton mill, three woolen mills, one machine shop, one foundry.
Lunenburg, ...	1,332	None.	0	None.
Leominster, ...	12,392	General.	8,000	Eight horn goods factories, one chair factory, one cotton yarn mill, two paper mills.
Lancaster, ...	2,478	Few sewers.	500	None.
Harvard, ...	1,139	None.	0	None.
Ayer, ...	2,446	None.	100	One tannery.
Shirley, ...	1,680	Private sewers.	400	One cotton mill, one woolen mill, one extract factory.
Groton, ...	2,052	None.	100	Three paper mills.
Ashby, ...	876	None.	0	None.
Townsend, ...	1,804	Few sewers.	200	One paper mill.
Pepperell, ...	3,701	Partial.	800	Four paper mills.
New Ipswich, N. H., .	911	-	-	- -
Mason, N. H., . .	459	-	-	- -
Nashua, N. H., . .	23,898	General.	-	- -
Brookline, N. H., . .	505	-	-	- -
Hollis, N. H., . .	910	-	-	- -
Greenville, N. H., .	1,608	-	-	- -

* Sewage purification works in use.

The North Branch of the Nashua River drains a portion of the northerly section of the State, and its drainage area extends into the State of New Hampshire.

The first sources of pollution of this branch are at Ashburnham, where the river receives sewage from a considerable part of the population of the villages of Ashburnham and South Ashburnham, including the sewage from four factories employing about 185 persons. No objectionable manufacturing wastes are produced at any of these factories.

Through the city of Fitchburg the river has a rapid fall, all of which is utilized for power purposes, and there are numerous mill ponds and factories along the stream.

The population of Fitchburg in 1900 was 31,531. The city is thoroughly sewered, the sewers being constructed on the combined plan, and discharging at twenty-one outlets located at convenient points along the river. Many of these outlets are objectionable, but the conditions about them are not much more objectionable than the general condition of the stream, which is offensive to sight and smell throughout much of its course in the city. Plans have already been prepared for the construction of an intercepting sewer to convey the dry-weather flow of sewage to a point below the city, where it will be purified on sand filter beds.

There are in Fitchburg about thirty mills, employing 5,100 persons, all the sewage from which is discharged into the river. These mills include paper mills, woolen mills, cotton mills and silk mills, from many of which enormous quantities of very foul wastes are discharged, which, together with the sewage, make the river a foully polluted stream. The fluctuations in the level of the water in the numerous mill ponds, by which portions of the bottom of the river are frequently exposed, increase the objectionable conditions.

About 5.5 miles below Fitchburg the river is joined by Monoosnock Brook, which receives the sewage of the main portion of the town of Leominster. Leominster had in 1900 a population of 12,392. The town is quite thoroughly sewered, the sewers taking some storm water as well as sewage. The principal outlet for the sewers is into Monoosnock Brook, about a mile above the point where it joins the Nashua River. There are no deposits in the vicinity of the outlet, as the stream into which the sewage is discharged has a rapid current, but the water below the outlet is badly polluted by sewage, especially at times of low flow, and the odor in the vicinity is objectionable. There are no houses in the immediate vicinity of the outlet or of the brook below the outlet. There is another small sewer outlet into Fall Brook, a tributary of the Nashua River, but the quantity of sewage discharged from this outlet is small.

There are numerous factories in the town, many of which do not produce any objectionable manufacturing wastes; but wastes are discharged either directly into the brook or into the sewers from several laundries, from factories where horn goods are made and from two woolen mills. At the latter mills no wool is scoured, the only wastes produced being those from washing and dyeing the cloth. Plans are now being prepared for the purification of the sewage of Leominster, including the objectionable manufacturing wastes.

The South Branch of the river rises in the towns of Princeton and Holden, and flows in a generally north-easterly direction. The water of this branch above Clinton is used for the water supply of the metropolitan district, and the pollution of streams above this point is prevented.

In Clinton there are several factories discharging wastes into the stream, and the river receives the effluent from the sewage purification works of the town.

The town of Clinton had in 1900 a population of 13,667. It is thoroughly sewered, the sewers being constructed on the separate plan, and the sewage is collected at a pumping station near the river and pumped to filter beds. At times of wet weather the flow of sewage is greatly increased by leakage of ground and surface water into the sewers, and at such times a small amount of sewage is allowed to discharge directly into the river opposite the pumping station. This outlet is situated near the highway, but there are no dwelling houses in its immediate vicinity, and as such overflows occur only at times when there is a large quantity of water flowing in the stream, objectionable conditions have not been produced.

About 750,000 gallons of sewage per day are received at the filtration area, and the effluent is discharged into a small brook which joins the South Branch about a quarter of a mile above its junction with the North Branch. At times the sewage has not been well purified, and the water flowing in the brook has had an objectionable appearance.

The principal factories discharging sewage directly into the river in Clinton are a cotton and a carpet factory, from both of which spent dyes are discharged into the stream; a small woolen mill, from which spent dyes and water used for washing cloth are discharged; and a large woolen mill, in which 200 persons are employed and about 15,000 pounds of wool are washed weekly, all of the sewage and wastes going into the river.

Both the North and South branches of the river where they unite at Lancaster are foully polluted, having a very offensive appearance and odor. Below the junction of the branches the first pollution which the river receives is at the village of Shirley, 7.5 miles below, where it is joined by a brook which receives a small amount of sewage from the village of Shirley and some wastes from three factories employing 400 persons.

At Ayer the river receives the flow of a brook which flows through the centre of the village, and which receives sewage and wastes from a tannery employing 100 persons. This brook below the tannery is very foul.

About 2 miles below Ayer the river receives the flow of Squannacook River, a large stream which enters it from the north-east, having a part of its drainage area in the State of New Hampshire. This river receives the sewage from a small population in Townsend, and sewage and wastes from a leatherboard factory which employs 12 persons. It also receives at West Groton sewage and wastes from a paper mill employing 40 persons, and from a leatherboard factory employing 20 persons.

At Paper Mill Village, 4.5 miles below Squannacook River, a paper factory employing 40 persons discharges sewage and wastes into the stream.

The town of Pepperell is situated on the river, about 3.5 miles above the New Hampshire line. The town has no regular system of sewers, but there are several sewers which serve a large number of houses in the village, discharging directly into the river. The outlets of these sewers appear to be unobjectionable, as the quantity of sewage discharged is small in comparison to the flow of water.

On the Nashua River and the Nissitisset River, a tributary which joins it just below Pepperell, there are four paper mills in the town employing about 550 persons, sewage and great quantities of wastes from which are discharged into the river.

Below the junction of the North and South branches the condition of the river improves considerably, but where it leaves the State the river is still a very badly polluted stream.

Examinations of the river have been made at various places for many years, and the averages of the chemical analyses of samples collected during the drier portion of each year are given in the following tables, together with the results of a special examination made in August, 1902: —

SPECIAL EXAMINATION OF NASHUA RIVER AND TRIBUTARIES, AUG. 4 AND 5, 1902.

[Parts per 100,000.]

SOURCE.	DAY SAMPLE.			NIGHT SAMPLE.		
	Free Ammonia.	Albuminoid Ammonia.	Chlorine.	Free Ammonia.	Albuminoid Ammonia.	Chlorine.
Flagg Brook, above Fitchburg,	.0056	.0444	.12	.0076	.0364	.13
Nashua River, above Fitchburg,	.0072	.0248	.14	.0032	.0204	.14
Nashua River, below sewer outlets in Fitchburg,	.1300	.0635	.88	.1600	.0615	.89
Nashua River, in Leominster, 1 mile below Fitchburg line,	.1500	.0590	.82	.1650	.0550	.92
Nashua River, in Leominster, 2 miles below Fitchburg line,	.1650	.0530	.87	.2150	.0545	1.03
Nashua River, just above Monoosnock Brook,	.1800	.0735	1.08	.2320	.0556	1.00
Monoosnock Brook, above Leominster sewer outlet,	.0256	.0344	.36	.0416	.0332	.57
Leominster sewer outlet,	.9700	.4800	5.75	.9000	.2500	3.40
Monoosnock Brook, below sewer outlet,	.0540	.1205	2.25	.3050	.0860	1.11
Monoosnock Brook, at mouth, 1 mile below sewer outlet,	.1900	.0960	.88	.3240	.0690	1.18
Nashua River, just below Monoosnock Brook,	.1900	.0685	1.06	.2480	.0608	1.01
Nashua River, ½ mile below Monoosnock Brook,	.2100	.0650	1.03	.2150	.0590	1.00

Flow of Nashua River,	74 cubic feet per second.
Flow of Monoosnock Brook,	17 cubic feet per second.

CHEMICAL EXAMINATION OF WATER FROM THE NASHUA RIVER AND ITS TRIBUTARIES. — AVERAGES FOR SIX MONTHS, FROM JUNE TO NOVEMBER, INCLUSIVE.

Nashua River, above Fitchburg.

[Parts per 100,000.]

Year.	Color.	Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
					Albuminoid.							
		Total.	Loss on Ignition.	Free.	Total.	Dis-solved.	Sus-pended.		Nitrates.	Nitrites.		
1898,	.73	3.81	1.92	.0015	.0228	.0204	.0024	.16	.0028	.0000	.84	.8
1899,	.58	3.70	1.81	.0010	.0198	.0178	.0020	.16	.0030	.0000	.70	.6
1900,	.44	3.36	1.33	.0010	.0185	.0162	.0023	.19	.0038	.0000	.58	.6
1901,	.49	3.41	1.57	.0018	.0182	.0153	.0029	.16	.0057	.0002	.65	.6
1902,	.67	3.83	1.79	.0015	.0196	.0171	.0025	.15	.0033	.0000	.80	.7

Nashua River, below Fitchburg.

1893,	.70	8.32	2.38	.0562	.0405	.0289	.0116	.73	.0097	.0030	.73	2.2
1894,	.66	9.18	2.22	.0987	.0425	.0308	.0117	.99	.0123	.0034	.64	2.4
1895,	.71	9.42	2.72	.1387	.0493	.0381	.0112	1.08	.0088	.0014	.82	2.6
1896,	.57	9.27	2.62	.0898	.0537	.0384	.0153	.95	.0127	.0030	.71	2.4
1897,	.67	7.62	2.50	.0512	.0518	.0389	.0129	.71	.0112	.0009	.79	2.1
1898,	.56	7.02	2.37	.0688	.0629	.0399	.0230	.56	.0097	.0016	.72	1.8
1899,	.53	10.12	2.95	.1507	.0848	.0537	.0311	1.03	.0055	.0013	.83	2.4
1900,	.42	9.55	2.42	.1575	.0825	.0479	.0346	1.03	.0080	.0015	.73	2.6
1901,	.42	8.45	2.58	.0964	.0508	.0347	.0161	.67	.0080	.0013	.69	2.2
1902,	.39	7.83	2.42	.1070	.0557	.0407	.0150	.68	.0072	.0012	.71	1.9

Monoosnock Brook, below Leominster.

1899,	.88	5.66	2.57	.0408	.0451	.0331	.0120	.53	.0072	.0009	.82	1.6
1900,	.62	4.32	1.83	.0162	.0437	.0289	.0148	.32	.0070	.0004	.75	.8
1901,	.56	4.47	2.13	.0304	.0359	.0254	.0105	.28	.0085	.0006	.73	1.2
1902,	.56	4.54	1.90	.0393	.0396	.0246	.0150	.35	.0087	.0005	.61	1.2

North Branch Nashua River, at Lancaster.

1892,	.48	9.75	2.10	.0422	.0274	.0237	.0037	1.11	.0450	.0010	–	3.0
1894,	.49	8.07	1.97	.0215	.0226	.0182	.0044	.97	.0295	.0011	.49	2.2
1895,	.51	8.28	2.39	.0318	.0272	.0214	.0058	1.01	.0284	.0034	.56	2.3
1896,	.57	6.97	2.17	.0253	.0322	.0253	.0069	.66	.0167	.0034	.60	2.0
1897,	.65	5.45	2.03	.0225	.0290	.0221	.0069	.40	.0153	.0015	.68	1.5
1898,	.48	6.33	2.10	.0409	.0345	.0263	.0082	.56	.0227	.0033	.51	1.7
1899,	.39	7.60	2.33	.0739	.0365	.0305	.0060	.75	.0153	.0028	.60	2.0
1900,	.29	7.17	1.55	.0545	.0326	.0264	.0062	.81	.0202	.0039	.52	2.1
1901,	.37	6.72	2.14	.0432	.0329	.0240	.0089	.54	.0087	.0021	.58	1.9
1902,	.40	7.96	2.66	.0757	.0324	.0267	.0057	.70	.0188	.0043	.58	1.8

South Branch Nashua River, at Lancaster, above Clinton Sewage Purification Works.

1902,	.38	8.90	2.69	.0331	.0437	.0292	.0145	1.05	.0102	.0008	.54	2.1

CHEMICAL EXAMINATION OF WATER FROM THE NASHUA RIVER AND ITS TRIBUTARIES.— AVERAGES FOR SIX MONTHS, FROM JUNE TO NOVEMBER, INCLUSIVE — *Concluded.*

South Branch Nashua River, at Lancaster, below Clinton Sewage Purification Works.

[Parts per 100,000.]

Year.	Color.	Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
					Albuminoid.							
		Total.	Loss on Ignition.	Free.	Total.	Dis-solved.	Sus-pended.		Nitrates.	Nitrites.		
1892, ...	.43	5.68	1.65	.0181	.0267	.0214	.0053	.59	.0150	.0006	–	1.8
1894, ...	.51	6.43	1.96	.0606	.0297	.0232	.0065	.57	.0104	.0020	.47	1.8
1895, ...	.52	4.89	1.85	.0229	.0251	.0191	.0060	.38	.0095	.0014	.59	1.5
1896, ...	.48	5.20	1.89	.0140	.0246	.0200	.0046	.44	.0100	.0009	.53	1.7
1897, ...	.66	4.56	1.97	.0131	.0265	.0212	.0053	.35	.0100	.0005	.59	1.4
1898, ...	.49	6.36	2.30	.0718	.0410	.0308	.0102	.44	.0030	.0022	.55	1.5
1899, ...	.57	9.29	2.52	.1641	.0524	.0383	.0141	1.03	.0072	.0026	.60	2.2
1900, ...	.35	10.20	2.15	.0584	.0392	.0280	.0112	1.45	.0597	.0035	.47	2.3
1901, ...	.33	9.18	2.62	.0265	.0314	.0242	.0072	.98	.0447	.0018	.49	2.4
1902, ...	.36	9.99	2.91	.0509	.0386	.0286	.0100	1.18	.0297	.0031	.52	2.2

Nashua River, at Pepperell.

1899, ...	.28	6.91	2.19	.0167	.0248	.0221	.0027	.78	.0137	.0008	.46	2.1
1901, ...	.37	6.00	2.06	.0154	.0266	.0230	.0036	.45	.0092	.0005	.55	1.9
1902, ...	.37	5.81	2.07	.0118	.0184	.0167	.0017	.49	.0162	.0006	.51	1.7

NEPONSET RIVER.

The Neponset River rises in the Neponset reservoir in Foxborough, and flows in a generally north-easterly direction to Dorchester Bay. In the upper and lower portions of its course the fall of the stream is rapid, and there are numerous factories and mills along the stream; but in the middle of the valley the river is bordered for many miles by the Fowl Meadows, through which the fall of the stream is slight and its current very sluggish. The principal tributaries are the east branch, or Canton River, which enters the main stream in the upper end of the Fowl Meadows, and is used for power by many factories in Canton, Stoughton and Sharon; and Mother Brook, which flows from the Charles River at Dedham into the Neponset River at Hyde Park, and is used extensively for mill power. About one-third of the flow of the Charles River at Dedham is diverted to Mother Brook.

The following tables give statistics in regard to the drainage areas and the population on them at various points: —

LOCALITY.	Distance above Mouth (Miles).	Drainage Area (Square Miles).	Population on Drainage Area.	Population per Square Mile.	Estimated Population discharging Sewage or Sewage Effluent into River.
Neponset River, above junction of east branch, or Canton River.	10.5	43.9	9,000	205	1,165
Neponset River, below junction of east branch, or Canton River.	10.5	75.0	19,600	261	1,815
Neponset River, above Mother Brook, . .	3.5	96.3	24,600	256	1,880
Neponset River, below Mother Brook, .	3.5	164.3*	43,200*	263*	2,750
Neponset River, at mouth (Milton Lower Mills).	0	175.8*	57,500*	327*	3,265

* Including one-third of the water-shed of the Charles River above Dedham.

CITIES AND TOWNS, CONSIDERABLE PORTIONS OF WHICH ARE WITHIN THE WATER-SHED OF THE NEPONSET RIVER.

LOCALITY.	Population in 1900.	Sewerage System.	Estimated Population discharging Sewage or Sewage Effluent into River or Tributaries.	Factories discharging Wastes into River or Tributaries.
Foxborough, ...	3,266	Few sewers.	165 (in asylum).	None.
Walpole, ...	3,572	None.	200	One rubber factory, one yarn mill, one batting mill, three paper mills.
Norwood, ...	5,480	Partial.	800	One gas works, one tannery.
Westwood, ...	1,112	None.	0	None.
Sharon, ...	2,060	None.	50	None.
Stoughton, ...	5,442	None.	100	One shoddy mill, one woolen mill, one rubber factory, one knit goods mill.
Canton, ...	4,584	None.	500	One silk mill, one woolen mill.
Dedham, ...	7,457	General.*	300	One dye works, one woolen mill, one carpet mill.
Hyde Park, ...	13,244	General.*	700	One hair factory, one shoddy mill, one woolen mill, one paper mill, one wool-scouring mill.
Milton, ...	6,578	General.*	50	None.
Boston (Dorchester district),	77,483	General.*	400	One paper mill.
Quincy, ...	23,899	General.*	0	None.

* South metropolitan district.

The Neponset River has its source in the Neponset reservoir in Foxborough, and a short distance below the outlet of the reservoir is joined by a brook which receives the effluent from the sewage purification works of the Massachusetts Hospital for Dipsomaniacs and Inebriates. The sewage is well purified, and the effluent does not have an objectionable effect upon the stream. The main portion of Foxborough is outside of the water-shed.

The first sources of pollution of the stream, of importance, are at the village of Walpole, where the stream is polluted by wastes from the washing of rubber; the wastes from the washing, bleaching and dyeing of 7,000 to 8,000 pounds of cotton yarns daily; the wastes of a cotton mill, consisting of about 8,000 gallons per day of waste water from bleaching and dyeing cotton, and about 20,000 gallons per day of water used for washing cotton; the wastes from a paper mill; and oily matters from cleaning cotton waste. The sewage from some of these mills is also discharged into the stream. The wastes from the yarn mill and the paper mill have a visible effect upon the river in the immediate neighborhood of the point of discharge, but below the village of Walpole the river is not objectionable in appearance or odor.

At East Walpole the river is very greatly polluted by wastes from two large paper mills and by sewage from a considerable number of operatives, and below these mills, as the river enters Norwood, the water is much discolored and has an offensive odor.

In Norwood the river is joined by Hawes Brook, which receives the wastes from a large tannery discharging about 500,000 gallons per day of very offensive wastes from the processes of tanning and wool-scouring, and an additional quantity of slightly polluted water used in the various processes of washing and rinsing. One of the other tributaries in the town of Norwood is polluted by the direct discharge of unpurified sewage from three establishments employing about 1,000 persons. From the mouth of Hawes Brook to tide water the Neponset River is grossly polluted, and offensive to sight and smell throughout the drier portion of the year. On the main stream below the junction with Hawes Brook are an ink factory and gas works, from which gas wastes and sewage from operatives are discharged into the stream. A short distance below the ink works the river is joined by a sewer owned by the town of Norwood which discharges wastes from a tannery and much domestic sewage into the river.

Below Norwood the main stream enters the Fowl Meadows, and is joined by the east branch, or Canton River, in the upper part of these meadows. This stream and its tributaries are polluted in Stoughton by the wastes from a large shoddy mill, where about 25,000 pounds of shoddies per week are treated; the wastes from a woolen mill, where about 1,000 pounds of cloth are washed and dyed per day; the waste from a knit goods mill, where cotton garments are bleached and washed; and the wastes from a rubber goods mill, resulting from the washing of rubber. The wastes from the shoddy mill enter Muddy Brook, a small stream, and render it offensive for a short distance below the mill. A considerable quantity of domestic sewage is discharged into the streams in Stoughton through private outlets.

In Sharon and Canton the stream receives a small amount of pollution from several mills, a very little domestic sewage from silk mills where about 200 to 300 pounds of silk per day are manufactured, and the wastes from a woolen mill where about 5,400 pounds of material are used in making woolen cloth; and all wastes, including the dust from shoddy-picking machines and water used in washing and dyeing cloth, are discharged into the stream. Much sewage from operatives in these and other mills and from dwelling houses is discharged into the stream. The stream below the silk mills in Canton is grossly polluted for a considerable distance, and in dry weather this stream has an objectionable appearance near the point where it joins the main river.

In the north-easterly part of Canton there is a woolen mill at which about 500 pounds of wool are scoured daily and cloth is treated and dyed, the wastes going into a small stream which enters the Neponset River below the east branch. This stream is grossly polluted throughout its length, but there are no dwelling houses in its neighborhood below the factory.

The water of Mother Brook, as it flows out of the Charles River at Dedham, is clean and satisfactory in appearance, and shows, from chemical analysis, little evidence of pollution. In the town of Dedham, Mother Brook is polluted at a dye works, where the wastes from rinsing and dyeing about 5,000 pounds of cotton per day are discharged into the stream; by wastes from a woolen mill, where about 1,000 pounds of woolen cloth are washed and dyed per day; and by the wastes from wool-scouring and dyeing at a carpet mill, where about 1,000 pounds of wool are scoured per day. The stream shows evidence of pollution below the woolen mill, and below the carpet mill it is discolored and turbid, but has not been found to be noticeably offensive in odor.

At Hyde Park there are several factories along the course of the brook, most of which discharge very little manufacturing waste into the stream; but a woolen mill near the mouth of the brook discharges the wastes resulting from the scouring of from 5,000 to 6,000 pounds of wool and the washing and dyeing of 3,000 pounds of woolen cloth per day, and below this mill the water is badly polluted. A considerable quantity of domestic sewage is discharged into Mother Brook in Dedham and Hyde Park from the mills and from private sewer outlets.

The Neponset River in Hyde Park receives a very large amount of manufacturing wastes, the principal pollution coming from wastes from a factory, where 1,500 pounds of hair are washed per day and about 500 pounds are dyed; wastes from a large steam laundry; wastes from a shoddy mill, where about 4,000 pounds per day of shoddies are washed and about 200 pounds per day are dyed; and wastes from a paper mill, where 30 tons of paper are made per day from wood pulp and rags.

Between Mattapan and tide water there is another large paper mill, where about 6½ tons of paper per day are made from rags and pulp, and a great quantity of wastes are discharged into the stream. The river is also polluted in Hyde Park by the sewage from operatives in the mills, and by large numbers of privies and private drains which discharge into the stream.

A considerable quantity of sewage from such sources is also discharged into the stream at Mattapan and Milton Lower Mills near the mouth of the river.

Special examinations of the waters of this stream and its tributaries have been made from time to time in past years, and the results will be found in the annual reports of the State Board of Health and in the special report on the improvement of the Neponset River published in 1897.

The character of the Neponset River and the changes from year to year are well shown by the following table of analyses, giving the yearly averages of monthly analyses of the water of the river above Hyde Park, and the results of analyses of the waters of the stream and its tributaries at other points in recent years: —

CHEMICAL EXAMINATION OF WATER FROM THE NEPONSET RIVER. — AVERAGES FOR SIX MONTHS, FROM JUNE TO NOVEMBER, INCLUSIVE.

Above Walpole.

[Parts per 100,000]

YEAR.	Color.	RESIDUE ON EVAPORATION.		AMMONIA.				Chlorine.	NITROGEN AS		Oxygen Consumed	Hardness.
					ALBUMINOID.							
		Total.	Loss on Ignition.	Free.	Total.	Dis-solved.	Sus-pended.		Nitrates.	Nitrites.		
1901, ...	1.64	6.71	3.14	.0115	.0412	.0345	.0067	.63	.0026	.0009	1.41	1.1
1902, ...	1.10	7.01	2.65	.0073	.0368	.0305	.0063	.87	.0038	.0013	.96	1.0
Below Walpole.												
1901, ...	1.42	6.32	3.17	.0119	.0377	.0317	.0060	.50	.0047	.0003	1.34	1.4
1902, ...	.84	7.32	2.45	.0080	.0340	.0266	.0074	.79	.0034	.0004	.84	1.5
At Norwood.												
1901, ...	1.50	22.88	8.68	.0243	.1680	.0993	.0687	3.56	.0072	.0020	2.45	6.7
1902, ...	–	34.80	8.58	.0504	.1937	.1190	.0747	5.67	.0040	.0006	3.63	12.9
At Hyde Park.												
1887, ...	1.18	8.20	2.22	.0053	.0402	–	–	.98	.0077	–	–	–
1888, ...	1.12	7.77	2.37	.0040	.0392	.0358	.0034	1.08	.0074	.0003	–	–
1893, ...	1.27	8.60	2.68	.0233	.0370	.0282	.0088	1.47	.0045	.0009	1.00	2.6
1894, ...	1.19	12.87	3.03	.0196	.0466	.0333	.0133	2.31	.0033	.0002	1.03	4.1
1895, ...	.97	10.01	3.07	.0341	.0440	.0373	.0067	1.51	.0042	.0001	1.05	3.7
1896, ...	1.26	10.41	3.12	.0162	.0431	.0395	.0036	1.68	.0033	.0001	1.26	3.3
1897, ...	1.30	11.64	3.34	.0336	.0494	.0417	.0077	1.81	.0037	.0001	1.31	4.0
1898, ...	1.28	8.82	3.52	.0161	.0505	.0398	.0107	1.02	.0023	.0002	1.30	2.7
1899, ...	1.14	16.24	4.51	.0264	.0936	.0693	.0243	2.20	.0032	.0002	1.76	5.7
1900, ...	1.10	10.59	2.99	.0400	.0576	.0381	.0195	1.45	.0048	.0005	1.07	3.2
1901, ...	1.43	13.26	5.09	.0224	.0802	.0591	.0211	1.69	.0036	.0006	1.82	4.2
1902, ...	1.02	12.57	4.19	.0360	.0640	.0547	.0093	1.72	.0035	.0004	1.29	4.0
At Milton Lower Mills.												
1901, ...	1.16	9.32	3.82	.0241	.0480	.0357	.0123	.93	.0077	.0006	1.29	3.1
1902, ...	.79	12.75	3.88	.0397	.0617	.0519	.0098	1.70	.0037	.0006	1.19	4.0

QUINEBAUG RIVER.

The Quinebaug River has its source in the towns of Wales and Brimfield, from which it flows in a generally south-easterly direction through the towns of Sturbridge and Southbridge into the State of Connecticut, where it is joined by the French River, and eventually discharges into the Thames River and thence into Long Island Sound.

The water-shed of the river is generally hilly, but there are numerous large reservoirs which are used for storage purposes, so that the dry-weather flow of the stream is large.

The following tables give statistics in regard to the drainage areas and the population upon them at various places: —

LOCALITY.	Distance Above State Line (Miles).	Drainage Area (Square Miles).	Population on Drainage Area.	Population per Square Mile.	Estimated Population discharging Sewage or Sewage Effluent into River.
Quinebaug River, above Southbridge, . .	7.5	100.0	3,900	39	650
Quinebaug River, below Southbridge (at Saundersdale).	4.5	128.2	14,000	109	7,850
Quinebaug River, at State line, . . .	0.0	157.7	15,600	99	9,000

TOWNS, CONSIDERABLE PORTIONS OF WHICH ARE WITHIN THE WATER-SHED OF THE QUINEBAUG RIVER.

TOWN.	Population in 1900.	Sewerage System.	Estimated Population discharging Sewage or Sewage Effluent into River.	Manufactories discharging Wastes into River.
Brimfield, . . .	941	None.	0	None.
Wales, ...	773	None.	250	Two woolen mills.
Holland, . . .	169	None.	0	None.
Sturbridge, . . .	2,058	None.	400	One tool factory.
Southbridge, . . .	10,025	General.*	8,000	One woolen mill, one optical factory, one print works.
Charlton, . . .	1,860	None.	200	One wire mill, one woolen mill, one satinet mill.
Dudley, ...	3,553	None.	150	One paper mill, one satinet mill.

* Sewage purification works in use.

The first sources of pollution of the river are near the head waters in Wales, where there are two woolen mills, employing together about 200 persons, sewage and wastes from which are discharged into the river. At one of these mills about 1,000,000 pounds of wool are scoured each year, but in the other no wool is scoured. Wastes from washing and dyeing cloth are discharged into the stream at both of these places. The water below these mills is very foully polluted. The river also receives a small amount of sewage from dwelling houses in Wales.

The next source of pollution is at East Brimfield, where the sewage from 30 operatives in a small factory is discharged into the stream.

At Fiskdale, in the town of Sturbridge, the river receives the sewage from 300 operatives in a factory; and a short distance below Fiskdale there is a tool shop which discharges sewage from 100 operatives, and a small quantity of wastes.

Just above the main village of Southbridge sewage from about 80 persons is discharged directly into the river. At Southbridge the river receives sewage from about 2,900 persons employed in factories, and wool-scouring wastes from washing about 1,500,000 pounds of wool per year, together with a very large quantity of polluting wastes from washing and dyeing cloth, and a small amount of highly colored wastes from grinding lenses at an optical factory. The wastes from the woolen mill pollute the stream greatly, and those from the optical factory discolor the water.

Just below Southbridge the river receives the effluent from the sewage purification works of the town. The town of Southbridge had in 1900 a population of 10,025. It is thoroughly sewered, the sewers being constructed on the separate plan, and the sewage is discharged on filter beds located below the village. The quantity of sewage discharged at the filter beds amounts to about 300,000 gallons per day, and at times a considerable proportion of this is discharged into the river without purification, as the works are not receiving proper attention.

Cady Brook, which rises in Charlton, enters the Quinebaug River from the north in Southbridge. On this stream there are several small factories employing together about 250 persons, sewage from which is discharged into the stream. The principal wastes which these factories produce are those from washing and dyeing cloth, and those produced in manufacturing shoddies.

At the village of Saundersdale, below Southbridge, the river receives highly colored wastes from a print works, together with the sewage from 300 operatives.

At West Dudley it receives the wastes from a small paper mill, and near the State line in that town the river receives sewage and wastes from a satinet mill employing 180 persons, the wastes consisting of water used for washing cloth, and spent dyes.

The large quantities of sewage and wastes which the river receives in Southbridge pollute the stream, and the condition of the water has been such as to be a cause of complaint from persons living below Southbridge.

Chemical Examination of Water from the Quinebaug River. — Averages for Six Months, from June to November, inclusive.

Above Southbridge.

[Parts per 100,000.]

Year.	Color.	Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
					Albuminoid.							
		Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		
1901, ...	.50	4.22	1.55	.0085	.0227	.0189	.0038	.18	.0038	.0001	.50	1.3
1902, ...	.50	3.94	1.66	.0075	.0270	.0203	.0067	.20	.0014	.0001	.52	1.0
Below Southbridge.												
1898, ...	.64	4.18	2.00	.0064	.0372	.0309	.0063	.18	.0050	.0003	.66	.8
1899, ...	.44	4.32	1.72	.0071	.0298	.0229	.0069	.23	.0048	.0002	.54	1.2
1900, ...	.40	4.31	1.56	.0168	.0324	.0211	.0113	.25	.0024	.0003	.52	1.0
1901, ...	.42	4.52	1.67	.0147	.0232	.0158	.0074	.19	.0050	.0005	.45	1.7
1902, ...	.36	4.12	1.45	.0068	.0224	.0179	.0045	.24	.0054	.0002	.43	1.2

TAUNTON RIVER.

The Taunton River drains an area in the south-eastern section of Massachusetts, discharging into Mount Hope Bay at Fall River. The water-shed of the stream is for the most part flat, and contains large areas of swamp, so that the flow of the stream is well maintained in dry weather. The effect of the tide is felt to a point just above Taunton, 17 miles from the mouth of the river.

The following tables give statistics relating to the water-sheds at various points and the population upon them: —

Locality.	Distance Above Mouth (Miles).	Drainage Area (Square Miles).	Population on Drainage Area.	Population per Square Mile.	Estimated Population discharging Sewage or Sewage Effluent into River.
Taunton River, above mouth of Town River,	35.5	76.2	54,600	716	1,500
Town River, at mouth, ...	35.5	60.4	11,100	184	35,320
Taunton River, below Town River, . .	35.5	136.6	65,700	481	36,820
Taunton River, just above mouth of Nemasket River.	28.8	183.9	67,600	368	36,865
Nemasket River, at mouth, ...	28.8	58.9	4,500	76	3,000
Taunton River, just below mouth of Nemasket River.	28.8	242.8	72,100	297	39,865
Taunton River, below Taunton, . . .	12.5	351.0	107,200	306	64,915
Taunton River, at mouth, ...	0.0	512.4	133,500	261	166,740

CITIES AND TOWNS, CONSIDERABLE PORTIONS OF WHICH ARE WITHIN THE WATER-SHED OF THE TAUNTON RIVER.

CITY OR TOWN.	Population in 1900.	Sewerage System.	Estimated Population discharging Sewage or Sewage Effluent into River.	Manufactories discharging Wastes into River.
Wrentham,	2,720	None.	0	None.
Foxborough,	3,266	Few sewers.	1,500	One leather factory, one foundry, one jewelry factory
Mansfield,	4,006	None.	200	Five metal working shops.
Norton,	1,826	None.	25	One woolen mill.
Easton,	4,837	None.	300	One shovel works.
Stoughton,	5,442	None.	0	None.
Avon,	1,741	None.	0	None.
Brockton,	40,063	General.*	35,000	Four shoe shops, one tack shop.
Abington,	4,489	Few sewers.	200	Two machine shops, one shoe shop.
Whitman,	6,155	None.	500	None.
Hanson,	1,455	None.	0	None.
East Bridgewater,	3,025	None.	300	None.
West Bridgewater,	1,711	None.	20	None.
Bridgewater,	5,806	None.	500	One leatherboard factory.
Halifax,	522	None.	25	One saw mill.
Plympton,	488	None.	20	Three saw mills.
Middleborough,	6,885	General.	3,000	None.
Raynham,	1,540	None.	50	One shoe shop, one tack shop, one saw mill.
Lakeville,	958	None.	0	One tack shop.
Taunton,	31,036	General.	25,000	Three cotton mills, two stove factories, one silverware factory, one paper mill, one bleachery.
Dighton,	1,802	None.	0	None.
Berkley,	949	None.	0	None.
Freetown,	1,394	None.	100	One bleachery, one saw mill, one cotton waste mill.
Somerset,	2,241	None.	0	None.
Fall River,	104,863	General.	100,000	None.

* Sewage purification works in use.

The upper portion of the water-shed of the Taunton River is drained by numerous large branches, the most important of which is the Salisbury Plain River, which rises in Stoughton and flows through Avon, Brockton and East Bridgewater. In Stoughton and Avon there are no serious sources of pollution.

The city of Brockton had in 1900 a population of 40,063. The city is provided with a general system of separate sewers, the sewage being collected at a reservoir near the Salisbury Plain River at the lower end of the city, and pumped to filter beds in the south-westerly corner of the city within the water-shed of the Coweeset River, another tributary to the Taunton. At times of wet weather there is a large leakage of ground and surface water into the sewers, and the flow of sewage is very much augmented. At such times a portion of the diluted sewage has been discharged directly into the river, but, as the flow of the river during these periods is high, no objectionable conditions are known to have been produced.

The quantity of sewage pumped to the filtration area amounts to about 750,000 gallons per day, all of which is thoroughly purified.

None of the factories in the city discharge sewage directly into the stream, most of them being connected with the sewers, and the others discharging the sewage into cesspools. A few of the factories discharge a small quantity of wastes into the river, these wastes consisting for the most part of water used for soaking leather, and a small quantity of acid wastes.

In East Bridgewater the Salisbury Plain River is joined by Beaver Brook, a practically unpolluted stream. No sewage or manufacturing waste is discharged into the stream at this place.

Just below the village of East Bridgewater the river receives the flow of the Satucket River, which rises in Abington and flows through Whitman. In Abington there are two small factories, employing about 30 persons, from which sewage and a small amount of manufacturing waste are discharged into the stream; and the sink drainage from a factory employing 100 persons, and the wastes from several large shoe shops, find their way into the river. The river also receives at Abington the sewage from a number of houses in the town.

At Whitman the river flows through Hobart's Pond, which is used directly as a source of water supply for the town. There is a large shoe factory at this place, from which some wastes are discharged into the stream below the pond, and a box factory which discharges a small amount of sewage.

In East Bridgewater this stream receives the sewage from 375 persons employed in a machine shop, and a small quantity of acid wastes.

About 1.5 miles below the Satucket River the Taunton River is joined from the west by the Town River, which flows through the towns of Easton, West Bridgewater and Bridgewater. The first source of pollution on this stream is in the village of North Easton, where a small amount of acid waste is discharged into the river from a tool factory. The river also receives the sewage from a small population at this place. Below North Easton the river receives the effluent from the Brockton purification works, which are described above.

In Bridgewater the Town River receives the overflow from a cesspool into which the sewage from a large shoe shop is discharged, and all of the sewage from a foundry and machine shop employing 225 to 250 persons.

Below the Town River the Taunton River flows for a considerable distance through a sparsely inhabited territory, until it is joined by the Nemasket River, which enters it from the south. At the head waters of the Nemasket River there are several large lakes, water from which is taken for the water supplies of the cities of New Bedford and Taunton. The town of Middleborough is situated on the Nemasket River, a short distance below the outlet of Lake Assawompset, the largest of these lakes.

The population of Middleborough in 1900 was 6,885. The town is provided with a system of sewerage, the sewage being discharged directly into the river. The principal sewer outlet is at Mayflower Avenue, where the sewage discharges into an open ditch, through which it runs for a distance of about 400 feet to the river, and the sewage in this open ditch is at times exceedingly offensive. There is no population in the immediate vicinity of the sewer outlet. The lower outlet is below the dam in the lower part of the village. This outlet discharges at some distance above the water, and the sewage falls into the bed of a tail race from a works operated chiefly at night, through which the sewage flows slowly to the river. There is an offensive odor about this outlet. The condition of the river at Middleborough is made more objectionable by a mill pond below the sewer outlets, the water of which is drawn down in such a manner as to leave large areas of the bottom exposed at times.

Besides the sewage discharged into the stream at Middleborough form the town sewers, the river receives the sewage from a factory in which 90 persons are employed.

Just below the point where the Nemasket River joins the Taunton River, the water of the river is used for the supply of the State Farm at Bridgewater. Until within about two years the water has been taken directly from the river for water supply purposes, but about two years ago a sand filter was constructed, and now all the water used in the institution is passed through this filter.

Below the Nemasket River the Taunton River receives no pollution until it reaches East Taunton, where it receives sewage from a cotton mill in which 425 persons are employed. Between East Taunton and Taunton it receives the flow of several small streams, into which a number of small factories discharge sewage and a very small quantity of waste.

The city of Taunton had in 1900 a population of 31,036. It is provided with a sewerage system constructed partly on the combined and partly on the separate plan. A system of sewage disposal has been designed for the city, and the sewerage system is being rebuilt so as to exclude all storm water. The principal outlet of the sewers at the present time is into the

Taunton River, in the lower section of the city at the walled edge of the stream. The river is affected by the tides, and has a rise and fall of about 3 feet, but at all times there is a considerable depth of water in front of the sewer outlet. The water of the river is very noticeably affected in the vicinity of the outlet, which is in the midst of a considerable population.

There are numerous factories in the city, many of which discharge sewage directly into the river, the others being connected with the sewers. There are no factories on the main river which discharge any very foul wastes into the stream, the principal wastes coming from the copper works below the main sewer outlet.

In the central portion of the city the river is joined by Mill River, which flows through a densely populated section. This river receives sewage directly from several small sewers and from the Taunton Insane Hospital. It also receives a large quantity of manufacturing wastes from cotton mills and dye works, and the stream is offensive.

About 2.75 miles below the main sewer outlet the river is joined by Three Mile River from the north-west. This stream rises in Foxborough and flows through the towns of Mansfield and Norton. At Foxborough near its head waters it receives the sewage from a considerable population in that town which is discharged directly into it, and a small amount of manufacturing wastes from shoe shops and straw factories. In Mansfield several jewelry factories discharge acid wastes into the river, and the river also receives sewage from about 200 operatives in the factories.

One of the branches of the river receives wastes from a wool-scouring establishment, in which 20,000 pounds of wool are scoured each day. The river below this latter establishment is very much polluted. In Taunton the sewage from about 100 persons employed in factories, and the wastes from a paper mill, a foundry and two cotton mills, are discharged into the Three Mile River.

Below Taunton the Taunton River is a tidal navigable stream for a distance of about 14.5 miles to the city of Fall River. At Fall River all of the sewage of the city is discharged into the stream through numerous outlets, which are described in Part I of this report.

The average results of analyses of samples of water collected during the drier months from the Taunton River and its tributaries are given in the tables which follow: —

CHEMICAL EXAMINATION OF WATER FROM THE TAUNTON RIVER AND ITS TRIBUTARIES. — AVERAGES FOR SIX MONTHS, FROM JUNE TO NOVEMBER, INCLUSIVE.

Salisbury Plain River, below Brockton.

[Parts per 100,000.]

YEAR.	Color.	RESIDUE ON EVAPORATION.		AMMONIA.				Chlorine.	NITROGEN AS		Oxygen Consumed.	Hardness.
		Total.	Loss on Ignition.	Free.	ALBUMINOID.				Nitrates.	Nitrites.		
					Total.	Dis-solved.	Sus-pended.					
1898, ...	.96	9.23	3.58	.0715	.0386	.0332	.0054	1.09	.0917	.0051	.88	2.6
1899, ...	.34	11.24	2.97	.0478	.0263	.0214	.0049	1.57	.1572	.0102	.43	3.3
1900, ...	.40	11.52	2.87	.0868	.0347	.0241	.0106	1.72	.1728	.0104	.57	3.2
1901, ...	.46	12.03	3.76	.1447	.0332	.0240	.0092	1.74	.1794	.0122	.63	3.4
1902, ...	.46	11.49	3.73	.1335	.0301	.0218	.0083	1.81	.2002	.0100	.52	3.5

Taunton River, at Bridgewater.

1887, ...	1.74	6.08	2.32	.0016	.0290	–	–	.60	.0059	–	–	–
1888, ...	1.68	5.50	2.40	.0013	.0293	.0278	.0015	.51	.0088	.0002	–	–
1900, ...	.69	5.79	2.00	.0044	.0268	.0233	.0035	.78	.0127	.0002	.84	1.1
1901, ...	1.22	5.67	3.39	.0065	.0411	.0308	.0103	.53	.0055	.0002	1.39	1.1
1902, ...	1.17	5.65	2.53	.0049	.0295	.0248	.0047	.69	.0133	.0002	1.13	1.1

Nemasket River, above Middleborough.

1887, ...	.41	3.43	1.35	.0004	.0184	–	–	.47	.0020	–	–	–
1888, ...	.73	3.81	1.72	.0003	.0230	.0208	.0022	.39	.0037	.0001	–	–

Nemasket River, below Middleborough.

1887, ...	.39	3.81	1.14	.0005	.0182	–	–	.50	.0045	–	–	–
1888, ...	.85	4.27	1.65	.0005	.0243	.0213	.0030	.47	.0157	.0002	–	–
1898, ...	1.27	4.90	2.83	.0031	.0301	.0278	.0023	.48	.0013	.0000	1.33	.9
1899, ...	.37	3.74	1.52	.0050	.0220	.0196	.0024	.51	.0037	.0001	.55	.5
1900, ...	.36	4.31	1.39	.0114	.0239	.0212	.0027	.68	.0038	.0002	.57	.8
1901, ...	.60	4.36	2.15	.0062	.0258	.0229	.0029	.50	.0033	.0001	.77	.8
1902, ...	.47	3.87	1.82	.0136	.0219	.0192	.0027	.56	.0038	.0002	.63	1.0

CHEMICAL EXAMINATION OF WATER FROM THE TAUNTON RIVER AND ITS TRIBUTARIES. — AVERAGES FOR SIX MONTHS, FROM JUNE TO NOVEMBER, INCLUSIVE — *Concluded.*

Taunton River, above Taunton.

[Parts per 100,000.]

YEAR.	Color.	RESIDUE ON EVAPORATION.		AMMONIA.				Chlorine.	NITROGEN AS		Oxygen Consumed.	Hardness.
		Total.	Loss on Ignition.	Free.	ALBUMINOID.				Nitrates.	Nitrites.		
					Total.	Dis-solved.	Sus-pended.					
1887, ...	1.25	5.73	1.94	.0031	.0276	-	-	.59	.0097	-	-	-
1888, ...	1.82	5.21	2.37	.0016	.0314	.0277	.0037	.43	.0067	.0002	-	-
1889, ...	1.86	-	-	0020	.0366	.0332	.0034	-	.0092	.0001	-	-
1890, ...	1.40	5.12	2.28	.0018	.0282	.0249	.0033	.51	.0078	.0001	-	1.5
1891, ...	1.03	5.37	2.17	.0006	.0235	.0212	.0023	.57	.0083	.0001	-	1.1
1892, ...	1.05	5.48	2.12	.0015	.0230	.0202	.0028	.59	.0072	.0001	-	1.2
1893, ...	1.33	5.72	2.47	.0063	.0260	.0223	.0037	.62	.0078	.0002	1.01	1.2
1894, ...	1.18	5.36	2.06	.0036	.0214	.0191	.0023	.67	.0028	.0001	.77	1.2
1895, ...	1.14	5.60	2.44	.0016	.0279	.0258	.0021	.67	.0083	.0001	1.00	1.2
1899, ...	.94	5.76	2.66	.0019	.0303	.0281	.0022	.61	.0034	.0001	.96	1.2
1900, ...	.66	5.92	2.01	.0070	.0248	.0229	.0019	.72	.0100	.0002	.76	1.1
1901, ...	.52	5.21	2.02	.0053	.0258	.0236	.0022	.63	.0120	.0001	.96	1.4
1902, ...	.80	5.77	2.36	.0109	.0245	.0212	.0033	.81	.0125	.0006	.83	1.2

Taunton River, below Taunton.

YEAR.	Color.	RESIDUE ON EVAPORATION.		AMMONIA.				Chlorine.	NITROGEN AS		Oxygen Consumed.	Hardness.
		Total.	Loss on Ignition.	Free.	ALBUMINOID.				Nitrates.	Nitrites.		
					Total.	Dis-solved.	Sus-pended.					
1898, ...	1.56	6.64	3.30	.0109	.0345	.0314	.0031	.61	.0082	.0003	1.51	1.3
1899, ...	.93	6.31	2.48	.0176	.0317	.0279	.0038	.72	.0060	.0004	1.04	1.2
1900, ...	.71	6.89	1.91	.0205	.0286	.0258	.0028	1.06	.0112	.0006	.76	1.5
1901, ...	1.01	6.15	2.45	.0293	.0275	.0255	.0020	.76	.0134	.0005	.92	1.6
1902, ...	.94	6.92	2.36	.1902	.0363	.0308	.0055	1.29	.0116	.0012	.90	1.4

TEN MILE RIVER.

The Ten Mile River rises in the town of Wrentham, and flows in a southerly direction through the towns of North Attleborough and Attleborough into the State of Rhode Island, where it unites with the Seekonk River. The river has a water-shed at the State line of 30.5 square miles, which contains a population of 16,600, or 544 persons per square mile of water-shed.

The following table gives the population of those towns considerable portions of which are within the water-shed of the river, together with the population from which sewage is discharged directly into the river, and the factories discharging wastes into the stream : —

Town.	Population in 1900.	Sewerage System.	Estimated Population discharging Sewage into River.	Manufactories discharging Wastes into River.
Attleborough, . .	11,335	General.	5,000	Five jewelry factories, one bleachery, one tannery.
North Attleborough, .	7,253	Few sewers.	1,500	Eight jewelry factories, one laundry, one gas works.
Seekonk, . . .	1,673	None.	0	None.
Wrentham, . . .	2,720	None.	400	Four jewelry factories.

The first source of pollution of the river is in the village of Plainville in the town of Wrentham, where the sewage from three jewelry shops, employing about 400 persons, is discharged into the stream, together with a small quantity of wastes, consisting chiefly of dilute acid. A small machine shop employing 3 or 4 persons also discharges sewage and a small quantity of wastes into the stream.

In North Attleborough, just below Plainville, there are six jewelry factories employing over 1,100 persons, and a laundry employing 30 persons, sewage and wastes from which are discharged into the river.

In the village of Robinsonville in the town of North Attleborough, wastes from two large jewelry factories, employing about 425 persons, are discharged into the river, together with the sewage from all of the operatives.

At Attleborough the river receives sewage from two town sewers, which serve the principal part of the thickly built up portion of the village. The town of Attleborough had in 1900 a population of 11,335. The sewers which are now in use were built originally as storm-water drains, but the sewage of a large part of the village is now discharged into them. The principal sewer outlet is at County Street, where a considerable flow of sewage is discharged at the edge of the stream just below the bridge. Practically the entire flow of the river above this outlet is frequently held back by a dam a short distance above, and the sewage discharged into the stream at such times creates a great nuisance, and this outlet has been the source of serious complaint. There are numerous buildings in the immediate vicinity of the outlet and near the river below the outlet. The lower outlet is at the head of a mill pond, at some distance from any population. The water of this mill pond is used for power purposes, and ice for domestic purposes is cut from the pond.

There are five jewelry factories on the river in Attleborough, each of which discharges a small quantity of wastes into the stream, and the sewage from about 475 operatives in three of these factories is also discharged directly into the river.

Below the main village of Attleborough there are two small manufacturing villages, known as Dodgeville and Hebronville. At each of these places there is a cotton factory employing about 250 persons, the sewage from which is discharged directly into the river. The sink drainage from a considerable population at these villages is also discharged into the river.

A short distance below Hebronville the river passes into the State of Rhode Island, where it is joined by the Seven Mile River, the principal part of the water-shed of which is within the State of Massachusetts. On this branch at South Attleborough there is a bleachery employing 100 persons and a tannery employing 40 persons, sewage and wastes from which are discharged into the stream. The Seven Mile River below these factories has a very objectionable appearance and odor.

The condition of the Ten Mile River in the vicinity of Attleborough is exceedingly objectionable. The water, in passing through the various mill ponds, however, has an opportunity for sedimentation, so that when it enters the State of Rhode Island the character of the water is considerably improved.

At East Providence, R. I., 10.5 miles below Attleborough, the water is used after filtration at a rapid rate through mechanical filters for the water supply of the town.

Samples of water collected from the Ten Mile River below Attleborough have been analyzed for a number of years, and the average results of the analyses during the drier months of each year are given in the tables which follow, together with the results of a special examination made in 1902: —

Special Examination of Ten Mile River, Aug. 12 and 13, 1902.

[Parts per 100,000.]

Source.	Day Sample.				Night Sample.			
	Free Ammonia.	Albuminoid Ammonia.	Chlorine.	Dissolved Oxygen.	Free Ammonia	Albuminoid Ammonia.	Chlorine.	Dissolved Oxygen.
Ten Mile River, above sewer outlets, Attleborough,	.0042	.0198	.52	73.0 87.3	.0034	.0212	.53	64.5 39.4
County Street sewer outlet, ...	3.5200	1.2800	21.96	–	1.9500	.4300	19.00	–
Ten Mile River, between County Street and Union Street sewer outlets.	.0180	.0292	.70	45.4 62.8	.0138	.0248	.77	38.0 28.0
Union Street sewer outlet, ...	.9100	.2300	–	–	.9000	.2000	3.41	–
Ten Mile River, ½ mile below Union Street sewer (middle of mill pond).	.0176	.0340	.83	59.6 109.2	.0052	.0298	.78	90.7 50.8
Ten Mile River, 1 mile below Union Street sewer (outlet of mill pond).	.0156	.0444	.87	58.9 79.8	.0088	.0372	.85	81.8 76.4
Ten Mile River, 1½ miles below Attleborough, .	.0060	.0376	.86	97.6 100.7	.0094	.0374	.84	54.3 55.4
Ten Mile River, 3 miles below Attleborough (outlet of second mill pond).	.0084	.0304	.70	71.4 93.6	.0108	.0272	.70	61.7 39.9

Flow of sewage from County Street sewer, ...	38,000 gallons per day.
Flow of sewage from Union Street sewer, ...	214,000 gallons per day.
Flow of river at Attleborough, ...	18 cubic feet per second.

Chemical Examination of Water from the Ten Mile River. — Averages for Six Months, from June to November, inclusive.

Below Attleborough.

[Parts per 100,000.]

Year.	Color.	Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Total.	Loss on Ignition.	Free.	Albuminoid.				Nitrates.	Nitrites.		
					Total.	Dissolved.	Suspended.					
1899,	.71	6.39	2.15	.0072	.0379	.0288	.0091	.62	.0133	.0004	.74	1.7
1900,	.47	6.19	1.60	.0125	.0363	.0241	.0122	.84	.0155	.0004	.49	1.8
1901,	.46	6.09	2.12	.0084	.0290	.0202	.0088	.71	.0222	.0004	.51	1.8
1902,	.41	6.49	1.83	.0073	.0394	.0237	.0157	.88	.0212	.0004	.52	1.9

WESTFIELD RIVER.

The Westfield River is a tributary of the Connecticut from the west, entering that stream a short distance above the boundary line between the States of Connecticut and Massachusetts. It is formed by three principal branches, which unite in the town of Huntington.

The following tables give data in regard to the drainage areas and the population upon them at various points: —

Locality.	Distance above Mouth (Miles).	Drainage Area (Square Miles).	Population on Drainage Area.	Population per Square Mile.	Estimated Population discharging Sewage into River.
West branch, at mouth,	22.8	96.0	2,800	29	350
Middle branch, at mouth,	24.8	53.0	1,200	23	0
East branch, at junction with middle branch,	24.8	172.3	3,900	23	0
Total of the three branches, at confluence,	22.8	324.3	8,100	25	550
Westfield River, just above Little River, at Westfield.	10.2	370.2	17,200	46	10,500
Westfield River, just below Little River, at Westfield.	10.2	455.2	20,500	45	10,800
Westfield River, at mouth,	0.0	518.4	27,100	52	12,500

Towns in the Water-shed of the Westfield River.

Town.	Population in 1900.	Sewerage System.	Estimated Population discharging Sewage into River.	Manufactories discharging Wastes into River.
Savoy,	506	None.	0	None.
Windsor,	507	None.	0	None.
Plainfield,	404	None.	0	None.
Cummington,	748	None.	0	None.
Peru,	253	None.	0	None.

TOWNS IN THE WATER-SHED OF THE WESTFIELD RIVER — *Concluded.*

TOWN.	Population in 1900.	Sewerage System.	Estimated Population discharging Sewage into River.	Manufactories discharging Wastes into River.
Worthington,	675	None.	0	None.
Chesterfield,	611	None.	0	None.
Washington,	377	None.	0	None.
Middlefield,	410	None.	15	One paper mill.
Becket,	994	None.	35	One paper mill.
Chester,	1,450	Partial.	100	None.
Huntington,	1,475	Partial.	300	One paper mill, one woolen mill.
Montgomery,	273	None.	0	None.
Blandford,	836	None.	0	None.
Russell,	793	None.	300	Two paper mills.
Granville,	1,050	None.	50	One drum factory.
Southwick,	1,040	None.	0	None.
Westfield,	12,310	General.	10,000	Three paper mills, one cotton mill.
West Springfield,	7,105	General.	1,500	Five paper mills.
Agawam,	2,536	Partial.	200	One paper mill.

The east and middle branches of the Westfield River above Huntington are practically free from pollution except from a few small saw mills. The west branch above Huntington receives pollution from Chester, Middlefield and Becket. At Becket there is a small paper mill employing about 35 persons, all of the sewage and wastes from which are discharged directly into the river; at Middlefield there is another small paper mill employing about 15 persons, from which sewage and wastes are discharged into the stream; and at Chester an emery mill, employing 50 persons, discharges sewage into the river, but no wastes are produced in the manufacturing processes.

At Huntington there is a woolen mill on the west branch, and the wastes, together with the sewage from 100 operatives, are discharged into the river. On the east branch below the junction of the east and middle branches in Huntington is a paper mill employing 75 persons, wastes and sewage from which are discharged into the river. There are several storm-water drains in Huntington, receiving a small amount of sewage from dwelling houses, which discharge into the river, but the water below Huntington is not noticeably polluted.

In the town of Russell there are two paper mills employing together about 295 persons, all of the sewage and wastes from which are discharged into the river. At the lower of these mills water for drinking purposes is sometimes taken from the river directly.

The first principal source of pollution of the Westfield River is in the town of Westfield, which is provided with a general system of sewerage. The population of Westfield in 1900 was 12,310. The sewerage system is built on the separate plan, but considerable ground and storm water enters the sewers. There are two outlets, the principal one draining the portion of the town south of the river and discharging just above the mouth of Little River, one of the principal branches. This outlet is located at the edge of the stream, at a point where there is a rapid current, and there are no dwelling houses near the river for a considerable distance below the sewer outlet. The second outlet is on the northerly side of the river, about a mile above the mouth of Little River. The outlet is located on the bank of the river and discharges at the edge of the water, and appears to be unobjectionable.

Besides the sewage discharged from the main sewers, manufacturing wastes and sewage are discharged from three paper mills employing about 230 persons, two cotton mills employing 165 persons, and a machine shop employing 65 persons. The principal paper mills are upon Little River, and the quantity of wastes discharged from them is very large.

Below Westfield the river flows for a distance of about 6 miles with a rapid current through a sparsely populated region to the village of Mittineague, which is in the towns of West Springfield and Agawam. In this village there are six paper mills employing an aggregate of about 675 persons, the sewage from which is discharged directly into the river. Large quantities of manufacturing wastes are also discharged into the river at this village.

There are three drains for sewage and surface water in the town of Agawam and two in the town of West Springfield, which discharge into the river at the village of Mittineague. The upper Agawam sewer receives the sewage from 17 or 18 houses, and discharges from a bluff just above the Mittineague bridge about 15 feet above the surface of the water in the river. The sewage trickles down over the rocks, but the quantity is so small that it does not appear to create a very offensive condition. The other two sewers on the Agawam side discharge below the thickly built up portion of the village.

The upper sewer on the West Springfield side discharges on the ground about 50 feet from the water, the sewage running over the stones into the water. There is a considerable deposit of solid matter in the river in the vicinity of this outlet at low water. The second sewer discharges into the river near the railroad station just at the edge of the water. There is a considerable deposit at the mouth of this sewer, consisting chiefly of sand brought down in times of storm.

The river below Mittineague has the appearance of a badly polluted stream, due chiefly to the manufacturing wastes discharged into it; but, as it flows for a distance of about 3 miles to the Connecticut River through a region which contains very few dwelling houses, it does not produce any serious nuisance except in the village itself.

A special examination of the river below Westfield was made Aug. 27

and 28, 1902, the results of which are given in the following table. Regular examinations have also been made of samples of water collected from the river above and below Westfield, the average results during the six dry months of each year being given in the tables which follow: —

SPECIAL EXAMINATION OF WESTFIELD RIVER, AUG. 27 AND 28, 1902.

[Parts per 100,000.]

Source.	Day Sample.			Night Sample.		
	Free Ammonia.	Albuminoid Ammonia.	Chlorine.	Free Ammonia.	Albuminoid Ammonia.	Chlorine.
Westfield River, above sewer outlets,	.0014	.0164	.12	.0040	.0134	.13
North side sewer outlet,	.8900	.5120	1.25	.5600	.2510	.60
Westfield River, between north side and south side sewer outlets,	.0030	.0144	.14	.0028	.0154	.15
South side sewer outlet,	.7900	.2750	1.55	.3200	.0730	.95
Little River, near mouth,	.0002	.0132	.15	.0006	.0140	.17
Westfield River, 1 mile below south side sewer outlet,	.0076	.0182	.16	.0030	.0206	.21
Westfield River, at mill pond above Mittineague, 6 miles below sewer outlet.	.0056	.0140	.18	.0022	.0184	.19

Flow of sewage from north side sewer, Westfield,	275,000 gallons per day.
Flow of sewage from south side sewer, Westfield,	2,250,000 gallons per day.
Flow of river at lower sewer outlet, Westfield,	183 cubic feet per second.

CHEMICAL EXAMINATION OF WATER FROM THE WESTFIELD RIVER AND ITS BRANCHES. — AVERAGES FOR SIX MONTHS, FROM JUNE TO NOVEMBER, INCLUSIVE.

East Branch, at Huntington.

[Parts per 100,000.]

Year.	Color.	Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Total.	Loss on Ignition.	Free.	Albuminoid.				Nitrates.	Nitrites.		
					Total.	Dissolved.	Suspended.					
1900,	.13	3.68	.98	.0006	.0107	.0101	.0006	.10	.0024	.0000	.27	1.8
1901,	.15	3.49	1.30	.0008	.0104	.0089	.0015	.10	.0033	.0000	.31	1.5
1902,	.28	3.38	1.50	.0013	.0127	.0106	.0021	.08	.0008	.0000	.46	1.4

Middle Branch, at Huntington.

1900,	.06	3.57	.90	.0005	.0067	.0064	.0003	.10	.0029	.0000	.16	1.8
1901,	.11	3.36	1.15	.0011	.0088	.0081	.0007	.10	.0040	.0000	.28	1.7
1902,	.16	3.33	1.39	.0009	.0088	.0080	.0008	.08	.0005	.0000	.36	1.7

CHEMICAL EXAMINATION OF WATER FROM THE WESTFIELD RIVER AND ITS BRANCHES. — AVERAGES FOR SIX MONTHS, FROM JUNE TO NOVEMBER, INCLUSIVE. — *Concluded.*

Westfield River, above Westfield.

[Parts per 100,000.]

YEAR.	Color.	RESIDUE ON EVAPORATION.		AMMONIA.				Chlorine	NITROGEN AS		Oxygen Consumed	Hardness.
		Total.	Loss on Ignition.	Free.	ALBUMINOID.				Nitrates.	Nitrites.		
					Total.	Dis-solved.	Sus-pended.					
1898, ...	.25	4.12	1.03	.0015	.0130	.0101	.0029	.11	.0027	.0001	.32	1.6
1899, ...	.17	4.18	1.32	.0012	.0142	.0121	.0021	.14	.0024	.0000	.34	2.0
1900, ...	.23	4.67	1.38	.0012	.0140	.0132	.0008	.16	.0050	.0000	.44	2.3
1901, ...	.14	3.88	1.48	.0012	.0118	.0096	.0022	.11	.0044	.0002	.33	1.9
1902, ...	.19	4.25	1.62	.0016	.0117	.0105	.0012	.12	.0035	.0001	.35	1.8

Westfield River, below Westfield.

1902, ...	.22	4.21	1.60	.0062	.0144	.0118	.0026	.14	.0062	.0002	.39	1.9

Westfield River, above Mittineague.

1898, ...	.24	3.98	1.52	.0069	.0147	.0113	.0034	.14	.0087	.0002	.31	1.7
1899, ...	.18	4.96	1.60	.0083	.0222	.0179	.0043	.21	.0052	.0002	.33	2.3
1900, ...	.24	5.17	1.41	.0202	.0300	.0240	.0060	.26	.0086	.0007	.45	2.3
1901, ...	.16	4.91	1.71	.0052	.0221	.0172	.0049	.20	.0085	.0005	.38	2.1
1902, ...	.17	4.63	1.64	.0066	.0143	.0112	.0031	.17	.0078	.0002	.32	2.2

SUMMARY.

BLACKSTONE RIVER.

The Blackstone River is grossly polluted, and is very offensive to sight and smell for many miles of its course below Worcester. Below the confluence with the Quinsigamond River in Grafton its character improves somewhat, though it is still offensive for the remainder of its course in the State. The chief cause of the present condition of the stream is the discharge of sewage and effluent from the sewers and purification works of the city of Worcester, but sewage and wastes from manufacturing processes in many factories and mills on the stream and its tributaries contribute to the pollution. The results of chemical analyses show an increase in the pollution of the stream in recent years, notwithstanding that a portion of the organic matter is removed from the Worcester sewage before it is discharged into the stream. Much work has been done recently in the city of Worcester in separating the sewage from the storm water and from the water of Mill Brook, and in the construction of filter beds for the purification of the effluent from the chemical precipitation works. If this work is continued, and the area of filter beds made sufficient for the purification of all of the sewage, a great improvement in the condition of the river will result.

Kettle Brook, one of the head waters of the river, is polluted in Cherry Valley in the town of Leicester by wastes from woolen mills, and the water of the stream for a considerable distance in this valley is badly discolored and offensive to sight and smell. After flowing through large ponds, however, it reaches the city of Worcester in a much-improved condition, and the effect of the pollution in Cherry Valley is not noticeable in the appearance or odor of the stream. In the southerly part of the city of Worcester, however, it is again greatly polluted by manufacturing wastes, but the pollution of this part of the river will be removed when the plans for taking these wastes into the sewers of the city of Worcester are carried out.

The Mill River is seriously polluted at times below Hopedale by the discharge of Hopedale sewage into the stream. Such disposal of the sewage is unnecessary, and all the sewage should be purified at the filtration area.

Charles River.

The Charles River in the greater portion of its course is in appearance clean and unobjectionable. It is grossly polluted by sewage at Milford near the upper end of its water-shed, and the odor of the stream is offensive for a distance of from 3 to 5 miles below the town. One of the tributaries of the river near its head waters is greatly polluted by manufacturing waste and sewage from Franklin, but the effect of this pollution disappears a few miles below the town. After passing Medway the evidences of pollution disappear, and as the stream passes Dedham and reaches Newton the water is clean in appearance and free from evidences of pollution; and even upon chemical analysis the evidences of pollution, aside from the excess of chlorine above the normal for this water-shed, are hardly distinguishable. The pollution of the stream is increased slightly by the discharge of manufacturing wastes from factories and mills in Newton and Waltham, but except in the immediate neighborhood of the points at which such pollution is discharged its effect on the stream is not evident to the senses.

The objectionable pollution of the stream at Milford and the great nuisance now existing there can be prevented by removing the sewage from the river and disposing of it in a proper manner. At Franklin the sewerage system can be extended to include the matters which now pollute the stream. The pollution of the stream in the lower portion of its course in Newton, Waltham and Watertown is easily preventable, since sewers are available in these places for the disposal of objectionable wastes.

CHICOPEE RIVER.

The Chicopee River and its main tributaries are in general clean in appearance, and nearly free from objectionable conditions caused by sewer outlets. Sewage from the towns of Ware, Palmer and Ludlow, and from the city of Chicopee, near its mouth, is discharged into the main stream or its tributaries, and the many factories and mills in the valley dispose of their wastes into the stream. The Ware River is noticeably polluted below Gilbertville and at Ware by sewage and the wastes from factories, but its condition is not very objectionable at the present time. One of the sewer outlets at Ware is located at the edge of the river, so that the sewage does not quickly mingle with the water; and this condition and the large quantity of sewage discharged at this single outlet causes a serious nuisance in the immediate neighborhood, and the evidences of the pollution of the river by sewage are quite noticeable to the senses for a considerable distance from the outlets, but the odor of sewage disappears after the sewage has become mingled with the water of the stream. The region about the outlets and below for several miles is very sparsely populated.

The upper waters of the Seven Mile River, a tributary of the Quaboag in Spencer, are grossly polluted by manufacturing wastes in that town, which form a serious local nuisance. Sewage is also discharged from the Spencer sewerage system into the Seven Mile River, causing the serious pollution of the stream at times. The pollution of the streams in the manner indicated is unnecessary, since the filtration area is of ample capacity to purify all of the sewage of the town.

The stream flowing from Monson into the Quaboag River is seriously polluted by manufacturing wastes, so that the effect of the pollution is noticeable at times throughout the length of this stream below Monson.

One of the sewer outlets at Chicopee Falls is located at the edge of the river, and the sewage discolors the stream for a considerable distance below the outlet, but the conditions are not otherwise objectionable. The main sewer outlet of the city of Chicopee discharges at the south bank of the river near its mouth, and there is an offensive odor in its neighborhood when the water is low. If the outlets of sewers in Chicopee should be extended into the river a sufficient distance to prevent the sewage from returning to the banks before mingling thoroughly with the water, the objectionable conditions about these outlets would be prevented, and the pollution of the river would not seriously affect the appearance or odor of the water.

CONCORD RIVER.

The main stream of the Concord River, between the junction of its principal tributaries at Concord and the city of Lowell, is clean in appearance and free from visible evidences of sewage pollution. The discharge of sewage and manufacturing waste into the stream in Lowell discolors the water and gives it an objectionable appearance at certain places, especially about the main sewer outlets of the city of Lowell near the mouth of the river. The objectionable conditions about the sewer outlets in this region could be remedied by extending the sewers into the stream.

The Sudbury River, one of the two principal tributaries of the Concord River, is very badly polluted by the manufacturing wastes and sewage discharged into the stream from the mills in the village of Saxonville, and the stream is objectionable in appearance and offensive in odor for a long distance below this place, and the evidences of pollution are noticeable in the appearance of the stream for a distance of about 7 miles in the drier portion of the year. With the exception of the pollution caused by the village of Saxonville, the Sudbury River does not receive any noteworthy pollution.

The Assabet River above Northborough is clean in appearance and unobjectionable. In this village it receives considerable manufacturing waste from woolen mills, which gives it an objectionable appearance for a considerable distance. Below Northborough its condition improves and the apparent effects of the pollution disappear. The stream is polluted at Hudson by sewage and manufacturing waste, and in dry weather has an objectionable appearance for a mile below the village. The condition of the stream improves further on, however, and again appears satisfactory during the remainder of its course to Maynard. At this point it is very badly polluted by the manufacturing wastes resulting from the scouring of a large quantity of wool and by the sewage from portions of the village, and the stream is objectionable in appearance and offensive in odor for 2 miles or more below this village. The evidences of the pollution are still noticeable where the river joins the Sudbury River.

CONNECTICUT RIVER.

The Connecticut River throughout most of its course in Massachusetts is not visibly affected by the pollution it receives from the great quantity of sewage and manufacturing wastes that find their way into the stream, and from the New Hampshire and Vermont boundary down to Northampton little evidence of pollution is shown by analysis. A serious local nuisance is created by the discharge of the sewage from the Northampton and Easthampton sewers through the Mill and Manhan rivers into the Connecticut River near Mount Tom, where, in addition to the sewage, a large quantity of manufacturing waste from a sulphite pulp mill is discharged into the stream.

The great quantity of paper mill wastes and sewage discharged into the stream at Holyoke noticeably affect the stream for a short distance below the city, on account of the floating matters from the manufacturing wastes; but otherwise, during the remainder of its course in the State the pollution discharged into the stream does not affect its appearance, or make the condition of the stream objectionable to those living near it.

The very serious nuisance caused by the discharge of the sewage of Northampton into the Mill River will be largely removed in about two years, when the sewage has been diverted to the Connecticut River, as required by statute. Plans are already prepared for the removal of the sewage of the town of Easthampton from Broad Brook to filtration areas near the Manhan River, which, when completed, will prevent the further pollution of this stream.

The discharge of the sewage of Amherst into Fort River badly pollutes the stream about the outlet, but the region is uninhabited, and the pollution of the stream does not appear to cause complaint as yet from those living in the valley below.

The discharge of sewage from the city of Holyoke above the dam across the Connecticut River at that place, where the sewage finds its way into the canals leading through the city, is very objectionable. Plans have been made for the removal of this sewage to an outlet below the city, but have not been carried out.

The conditions about one of the outlets in South Hadley and several of the outlets in Holyoke are offensive on account of the collection of sewage in the neighborhood of the outlets. Objectionable conditions also exist about some of the outlets in Springfield, and at one of the outlets in West Springfield, where sewage is discharged at the edge of the river. These objectionable conditions could be removed by extending the sewer outlets so as to discharge into the water at all times well away from the shore.

Deerfield River.

The Deerfield River flows through a very sparsely populated region, and the sanitary condition of the stream is excellent throughout its course. The stream receives a small amount of direct sewage pollution from sewers in Shelburne Falls and from the town of Greenfield, the sewage of which is discharged into the Green River, a tributary of the Deerfield a short distance above the mouth of the latter stream.

Of the tributaries of the Deerfield River, the Green River is the only one which receives any considerable amount of sewage pollution. The sewage discharged into this stream from the town of Greenfield greatly pollutes the water, and the appearance and odor of the stream are objectionable at times of very low flow between the lower sewer outlet and the Deerfield River. Both of the principal sewer outlets discharge at the edge of the stream, and the odor of the sewage is noticeable in the neighborhood of these outlets.

French River.

This stream is seriously polluted by manufacturing wastes at several points in its course, and below Webster, as it flows out of the State, its appearance in the drier portion of the year is filthy and the odor objectionable. The chief causes of the objectionable condition of the river in this region are the manufacturing wastes from the woolen mills at Webster, and the sewage of the town which is discharged into the stream at several outlets. The conditions about the sewer outlets were not noticeably more objectionable than the general condition of the stream. The other serious pollutions are at Rochdale, North Oxford and Oxford, and the river is seriously polluted and objectionable in appearance and odor at times for a short distance below these villages.

HOOSICK RIVER.

This stream is filthy and offensive in appearance and odor in the portion of its course between North Adams and Williamstown. The south branch is seriously polluted by sewage and manufacturing wastes from mills in Adams, about 7 miles above North Adams, and is also polluted by the sewage from two small sewers in North Adams. The south branch above Adams is practically an unpolluted stream, and below Adams the pollution does not render the condition of the stream objectionable except for a short distance below the village. The waters of the north branch above North Adams are polluted somewhat by the wastes from a woolen mill, but are not objectionable in appearance or odor above the city. Nearly all of the sewage and manufacturing wastes have been diverted from this stream, so that the great nuisance that formerly existed in this portion of the river has largely been transferred elsewhere. The greater portion of the sewage of North Adams is discharged into the Hoosick River, about a mile below the junction of the north and south branches, at a place where the stream is already greatly polluted by manufacturing wastes from factories a short distance above. The stream at the sewer outlet has a rapid current, and the conditions about the sewer outlet itself, while very objectionable, are not noticeably worse than the general condition of the stream, which is offensive in appearance and odor. At times of dry weather much of the water of the stream is held back by dams at night and on Sundays, and at such times the condition of the stream is much worse than usual.

As it passes through Williamstown the appearance of the river gradually improves, but it is still very badly polluted as it flows into the State of Vermont.

HOUSATONIC RIVER.

The Housatonic River at the junction of the main branches at Pittsfield was, up to the latter part of 1902, very badly polluted by sewage and manufacturing wastes discharged into the stream from the city sewers and from a large number of woolen mills. In the latter part of the year, by the completion of the sewage purification system, a large portion of the sewage was removed from the stream and its condition became much improved. It is still seriously polluted by sewage and manufacturing wastes from the city sewers and from mills on the tributaries of the stream in Pittsfield, and the effect of the pollution is noticeable below the city. The appearance of the stream improves in its course to Lenox. It receives much sewage and manufacturing waste from the towns of Lenox, Lee and Great Barrington, in addition to that which it receives above, which noticeably affect the condition of the stream at several points.

The conditions about the outlets at Lenox, Lee and Great Barrington were not objectionable when examined.

The east branch of the Housatonic River above Pittsfield is polluted by manufacturing wastes at Hinsdale and by manufacturing wastes and sewage at Dalton. The river is very offensive to sight and smell for a considerable distance below the village of Hinsdale, and is very noticeably polluted at Dalton, but was not found to be offensive in odor at this place when examined.

The west branch of the river in the city is very badly polluted by manufacturing wastes, and is offensive in appearance and odor.

The south-west branch is also badly polluted by wastes from a woolen mill in the westerly part of Pittsfield, which make it unsightly and offensive through the remainder of its course.

Merrimack River.

The Merrimack River receives a great quantity of pollution by sewage from cities and towns in New Hampshire and in the valley of the Nashua River before it enters the State of Massachusetts, but this pollution does not affect the appearance of the stream immediately above Lowell. The effect of the great quantity of sewage and manufacturing wastes discharged into the stream at Lowell is not sufficient to render the water of the stream objectionable to sight or smell below the city, and the stream was used until within ten years as a direct source of water supply at Lawrence, 9 miles below.

The effect of the discharge of sewage and manufacturing waste into the river at Lawrence is noticeable for a considerable distance below the city at times of low flow in the stream, chiefly on account of floating matters from the manufacturing wastes.

The sewage of Haverhill is discharged at many outlets, but the quantity of manufacturing wastes discharged into the river here is small, and the condition of the river below the city is not very different from its condition above.

The river also receives sewage from the city of Newburyport, close to its mouth.

There are serious local nuisances about many of the sewer outlets in Lowell, Lawrence and Haverhill, caused by the discharge of sewage at the banks of the river, where at low water it flows over the ground for a considerable distance before reaching the water, and there are large deposits of solid matter and pools of sewage at many of these outlets, which in hot weather are very offensive. The objectionable conditions about such outlets could be prevented by extending the outlets into the stream, where they would be covered with water at all times, and the sewage could become thoroughly mingled with the water before it could return to the banks.

Stony Brook, which enters the Merrimack River above Lowell, is badly polluted, chiefly by manufacturing wastes, and its condition is objectionable.

The Spicket River in its course through Lawrence is greatly polluted by manufacturing waste, and to some extent by sewage, and is in a very unsatisfactory sanitary condition.

Little River, as it flows through Haverhill, is also seriously polluted by manufacturing wastes and sewage, and is offensive to those living in the neighborhood.

Miller's River.

Miller's River throughout much of its course appears clean and free from pollution. The sewage of Athol has a noticeable effect on the appearance of the river for a short distance below that town, but the effect disappears in the mill pond below. With this exception, the presence of pollution in Miller's River is not detectable except by analysis, unless in the immediate neighborhood of the sewer outlets. The sewer outlets at Athol and Orange are not in themselves seriously objectionable, and the most seriously objectionable outlet is at Miller's Falls, where deposits collect at the edge of the river.

The sewage of Gardner, much of which is discharged unpurified into a brook, greatly pollutes this stream, but the region is uninhabited, and the noticeable effect of the pollution disappears after the stream joins the Otter River.

The river is also polluted at Winchendon by manufacturing wastes.

Nashua River.

The Nashua River is a highly polluted stream. The North Branch below Fitchburg is offensive to sight and smell, on account of the sewage and manufacturing waste discharged into it at Fitchburg and Leominster. The sewage of Clinton, the only town of importance on the South Branch, is conveyed to a filtration area. The main stream below the junction of the North and South branches is objectionably polluted, and has an offensive odor at times of low flow for several miles, but the visible effect of the pollution disappears before the stream passes out of the State.

Plans for the removal and purification of the sewage and much of the manufacturing waste which pollute the stream at Fitchburg and Leominster are under consideration, and if put into effect would remove the chief causes of the present objectionable condition of the stream.

Neponset River.

The Neponset River is grossly polluted throughout its length from Walpole to tide water, and an offensive odor is noticeable for a long distance from the stream in the drier portion of the year.

The pollution of this stream is caused almost wholly by manufacturing wastes from the numerous factories and mills along the stream and its tributaries.

A statute has recently been enacted to prevent the entrance of manufacturing waste, and prohibiting the discharge of sewage into the stream or its tributaries.

Quinebaug River.

The Quinebaug River is at times noticeably polluted below Southbridge by sewage and manufacturing wastes from that town. Provision has been made for the purification of the sewage by filtration, but the works do not receive sufficient care, and much unpurified sewage is discharged into the river.

Above Southbridge the stream flows through a sparsely populated region, and receives in general but little pollution; but at Wales, near the head waters, the stream is badly polluted by wool-scouring wastes from several woolen mills, and this pollution is evident in the appearance of the stream for a considerable distance from the village.

Cady Brook, one of the tributaries of the Quinebaug River which rises in Charlton, is badly polluted by sewage and manufacturing wastes from several small factories in the southerly part of Charlton. This pollution makes the water of the brook turbid and offensive to smell through much of its course to the Quinebaug River. By collecting all of the sewage and manufacturing wastes of the town of Southbridge into the sewers, and properly maintaining the filtration area, the principal pollution of this stream could be removed, and the sanitary condition of the main stream would then be satisfactory.

The nuisances caused by manufacturing wastes at Wales and Charlton would require local treatment, since there are no sewers at these places.

Taunton River.

The sanitary condition of the Taunton River and of most of its principal tributaries is in general satisfactory. A small quantity of sewage finds its way into one of the tributaries at Brockton and pollutes this stream, and a very small quantity of sewage enters another tributary at Bridgewater, but the condition of the streams at these places is not seriously objectionable.

The most unsanitary condition found in the Taunton River water-shed exists at Middleborough, where the sewage of the town is discharged into the Nemasket River. One of the outlets for this sewage discharges into a ditch several hundred feet back from the river, through which the sewage flows with a sluggish current, and is very offensive in the drier portion of the year. The other outlet discharges into the tail-race of a mill, in which little or no water flows during much of the time. The effect of the pollution of the Nemasket River is not noticeable in the Taunton River except by analysis after the Nemasket River joins that stream. The Taunton River is used as a source of water supply at the State Farm, after filtration.

The condition of the Mill River in Taunton, while still objectionable, has been greatly improved by the removal of the sewage from the stream by the extension of the new sewerage system in this district; and when the remainder of the sewage is removed, the sanitary condition of this stream will become satisfactory.

The principal sewer outlet discharging into the Taunton River at the present time is the main outlet of the sewers of the city of Taunton, which discharges into the stream below the city. The sewage is visible in the water for a considerable distance about the outlet, but after becoming mingled with the water lower down stream its presence is not noticeable except by analysis.

The sewer system of the city of Taunton is being extended to all parts of the city, and the works, when completed, will provide for the removal of the sewage from the river to a filtration area, where it is to be purified before being discharged into the stream.

Ten Mile River.

The Ten Mile River is badly polluted by the sewage of Attleborough, and by manufacturing wastes discharged into the stream at Plainville, North Attleborough and Attleborough, and the stream is objectionable in appearance and odor for a considerable distance below the sewer outlets. Its condition further down improves, however, and the stream is used as a source of water supply in Rhode Island, after filtration.

The principal sewer outlet is sometimes a very serious nuisance, on account of the fact that the water of the stream is held back for considerable periods by a dam a short distance above the sewer outlet, when the sewage flows in the open channel of the river, collecting in pools and becoming very offensive.

At the lower outlet the sewage is discharged into the head of a mill pond, and the outlet itself is not seriously objectionable.

The quantity of sewage and manufacturing wastes discharged into the river at Attleborough is greater than the river is capable of removing in the drier portion of the year without becoming objectionable. Plans for the purification of the sewage have been prepared, but no further action has been taken.

Westfield River.

The Westfield River drains a sparsely inhabited region, and its waters are nearly everywhere clean and free from noticeable evidences of sewage pollution. The west branch receives considerable manufacturing waste in the small villages above Huntington, and the stream is sometimes rendered turbid by mineral wastes in this village. The waters of the east and middle branches are not polluted by sewage or manufacturing wastes excepting to a slight extent at mills in the village of Huntington.

At Westfield the sewage of the town is discharged into the stream at two outlets, so located that they are not objectionable; and the effect of the sewage on the stream quickly disappears.

A considerable quantity of polluting matter is discharged into the Little River, a tributary of the Westfield below the town of Westfield, which noticeably affects the stream about the points of discharge. The sewer outlets at West Springfield and Agawam are in some cases badly located, so that the sewage runs over the ground before entering the water, and objectionable deposits exist at some of these outlets. The quantity of sewage discharged at these outlets is small, and the objectionable conditions about them could be removed by extending the sewers into the stream so that the sewage would not collect on the banks.

A Comparison of the Condition of the Different Rivers at the Points at which they are polluted by the Sewage of Cities and Towns.

The results of the examinations show that sewage may be discharged into a stream without creating objectionable conditions, unless the water of the stream is used for water supply purposes or for certain manufacturing or mechanical purposes, if the flow of the stream is sufficient to dilute the sewage thoroughly, and provided also that the sewage be discharged into the stream through a properly constructed outlet.

In making the investigations of the effect of sewage disposal, information has been collected to determine as closely as practicable the relation that the quantity of sewage discharged into the various streams bears to the flow of the streams at the points of pollution, and the results are presented in a table which follows.

As has already been shown, there is a wide variation in the flow of streams in different seasons of the year, the period of greatest flow being in the winter and spring, from December until May; and the period of least flow being in summer and autumn, from June to November. Since there is comparatively little variation in the quantity of putrescible organic matter discharged in the sewage from a given population in different seasons of the year, the effect of the sewage upon a stream is greatest in summer, when the flow is least, and when the other conditions are most favorable for the development of offensive odors and objectionable conditions.

The flow of some of the streams of Massachusetts, as already indicated, has been carefully measured for many years, and from these measurements the average flow of these streams in the drier portion of the year can readily be determined. In the cases of other streams polluted by sewage, measurements of the flow have been made from time to time; and from the results of these observations, taken in connection with the information now available as to the areas of the water-sheds and as to the quantity of water held in storage in reservoirs on the water-sheds of these streams for the maintenance of the flow in dry weather, it is practicable to estimate quite closely their average flow in the drier portion of the year.

NAME OF STREAM.	Water-shed (Square Miles).	Estimated Dry-weather Flow (Cubic Feet per Second).	Population discharging sewage into Stream within a Short Distance of the Point indicated.	Flow per 1,000 Persons discharging Sewage (Cubic Feet per Second).	Total Population discharging Sewage into River above Point indicated.
Connecticut River, below Northampton and Easthampton,	8,539	3,500	21,500	162.8	48,000
Chicopee River, at Indian Orchard, ...	696	209	3,000	69.7	15,250
Quaboag River, at Palmer, ...	213	73	1,200	60.8	2,950
Connecticut River, below Holyoke, including Northampton and Easthampton.	8,627	3,535	66,000	53.6	91,000
Connecticut River, below Springfield, including cities and towns within 30 miles above.	9,922	3,970	144,000	27.6	198,000
Merrimack River, below Lowell, excluding all other cities and towns.	4,622	2,265	95,000	23.8	-
Merrimack River, above Lowell, including Concord, Manchester and Nashua, N. H.	4,127	2,022	90,000	22.5	129,000
Chicopee River, at Chicopee, ...	730	219	10,000*	21.9	27,150
Miller's River, at Athol, ...	282	102	5,000	20.4	8,700
Merrimack River, below Lawrence, including Lowell, .	4,828	2,363	160,000	14.8	-
Miller's River, at Orange, including Athol, . . .	322	116	8,000	14.5	11,700
Housatonic River, at Dalton, ...	55	16	1,200	13.3	1,700
Merrimack River, below Haverhill, including cities and towns within 30 miles above.	4,882	2,392	190,000	12.6	348,000
Westfield River, at Westfield, ...	455	123	10,000	12.3	10,800
Merrimack River, below Lowell, including Concord, Manchester and Nashua, N. H.	4,622	2,265	185,000	12.2	-
Ware River, at Ware, ...	192	60	6,000	10.0	8,000
French River, at Webster, ...	93	50	7,200	6.9	7,430
Taunton River, at Taunton, ...	351	158	25,000	6.3	29,915
Nemasket River, at Middleborough, ...	59	15	3,000	5.0	3,000
Fort River, at Amherst, ...	41	10	2,000	5.0	2,000
Manhan River, at Easthampton, ...	70	18	4,000	4.5	4,000
Green River, at Greenfield, ...	90	23	6,000	3.8	6,000
Ten Mile River, at Attleborough, ...	21	8	3,000	2.7	6,900
Housatonic River, at Pittsfield, ...	129	43	20,000†	2.1	21,700
Hoosick River, at Williamstown, including North Adams,	177	46	25,000	1.8	29,775
Charles River, at Milford, ...	11	3	2,000	1.5	2,000
Hoosick River, at North Adams, ...	119	32	23,000	1.4	27,775
Broad Brook, at Easthampton, ...	12	4	3,000	1.3	3,000
North Branch, Nashua River, below Leominster, including Fitchburg.	95	38	36,000	1.1	36,500
North Branch, Nashua River, at Fitchburg, . . .	62	25	28,000	0.9	28,500
Mill River, at Northampton,.	55	14	17,500	0.8	18,000
Monoosnock Brook, at Leominster, ...	11	5	7,000	0.7	7,000

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* Not including those discharging sewage through main sewer outlet at mouth of river.

† Previous to the introduction of sewage purification works.

Referring to the table of flow of the Sudbury River, in a previous portion of this report, it will be seen that in nearly every year there is a period of very low flow in the summer season. In a few of the years this period is short, covering only one or two months, while in other years the period of very low flow continues for five and even six months. The longer periods of very low flow represent in general the most objectionable conditions under which sewage can be discharged into a stream, and if objectionable conditions do not appear in these periods, they will probably not appear in the short periods of somewhat lower flow. There are, of course, many cases in which it is important to consider the conditions that may exist in periods of extreme low flow, even if they continue for only a few days or even hours, but objectionable conditions of this sort are usually local and do not affect the stream as a whole. From the measurements of the various streams and the other information available the dry-weather flow of the different streams has been estimated, and is presented in the table.

It would have been impracticable to make measurements of the sewage from all of the sewers of the different cities and towns discharging sewage into the streams. As already indicated there are very great variations in the quantity and character of sewage discharged from the different cities and towns, on account of differences in the quantity of water used, the leakage into the sewers, the quantity of manufacturing wastes, etc.; but in general it has been found that the quantity of putrescible organic matter discharged in the sewage of the different cities and towns is approximately proportional to the population connected with the sewers, unless the character of the sewage is greatly affected by manufacturing wastes.

Information has been collected to determine as nearly as possible the population discharging sewage directly into each of the rivers, and the results are presented in the table. In the third column is given the population discharging sewage into the stream within a short distance above the point indicated, and the total population discharging sewage into the stream or its tributaries above the point indicated is given in the last column.

The various streams which are polluted by sewage have been arranged in the order of the ratios of the dry-weather flow of the stream to each 1,000 of the population discharging sewage into the stream immediately above the point indicated. No account is taken in this ratio of the effect of sewage discharged into the stream at a considerable distance above the point indicated, although in some cases the effect of such pollution upon the water of the stream has not disappeared. Some of the rivers, such as the Deerfield, which is very slightly affected by sewage, and the Blackstone and Neponset, which are grossly polluted, have not been included in the table, and others have been omitted in cases where definite data are lacking.

It will be seen that at the top of the list are those streams in which objectionable conditions have not been found, excepting in cases where local nuisances exist by reason of an improperly located sewer outlet. The first case given in the table in which the water of a stream is rendered generally objectionable by pollution is that of the French River at Webster. At this place it will be found, by reference to the details of the examination of this stream, that the quantities of manufacturing wastes from wool scouring and cloth washing discharged into the stream are so great that the effect of the sewage alone is not determinable.

The sewage of the city of Taunton is being discharged into the Taunton River temporarily, pending the completion of the works and the installation of a sewage purification system. It does not appear that the river is badly polluted, except in the neighborhood of the sewer outlet at the present time.

The Nemasket River below Middleborough has been the subject of serious complaint, and the Green River at Greenfield has been objectionable in dry weather. The Fort River at Amherst flows through an uninhabited region for a long distance below the sewer outlet, so that attention has not been directed to the condition of the stream. The Manhan River has not thus far been made seriously objectionable by the Easthampton sewage, evidently on account of the fact that this sewage is discharged into a large pond, through which it flows before entering the river.

The results of the investigations show that where the quantity of water available for the dilution of the sewage in a stream exceeds about 6 cubic feet per second per 1,000 persons discharging sewage, objectionable conditions are unlikely to result from the gross pollution of all the water of a stream in dry weather. Under favorable circumstances, such as in cases where the sewage is discharged at many outlets into a large body of water, objectionable conditions may not result where the dilution is somewhat less than 6 cubic feet per second per 1,000 persons; but objectionable conditions have resulted in all of the cases thus far examined where the flow has been less than 3.5 cubic feet per second per 1,000 persons discharging sewage into the stream.

FOOD AND DRUG INSPECTION.

FOOD AND DRUG INSPECTION.

The work of the year 1902 completes nearly twenty years of food and drug inspection by the State Board of Health, this department having been organized and the work begun in 1883. A general food statute had been enacted in 1882, as a result partly of investigations made by the Board in previous years and partly on account of agitation of a national character, which resulted in the formation of a national committee in 1880 upon this subject. This committee offered a prize for a draft of a law for the prevention of food adulteration. The best draft was that of Professor Wigner of London, which was made the basis of the new law which, after its enactment in 1882, has stood the test of twenty years, and has been copied with few amendments in other States.

Of the operation of this act, the inspection made, the prosecution of offenders conducted and the benefits secured to the people of the State, the reports of the past twenty years give ample evidence.

The following report treats of the operations of the Board under the provisions of this act during the year ended Sept. 30, 1902. The report made to the Legislature in January, 1903, "of the number of prosecutions made under the act and an itemized account of the money expended in carrying out the provisions thereof" is also embodied in this annual report.

The following persons comprised the force employed by the Board during the year in this department: —

ALBERT E. LEACH,	*Analyst.*
C. A. GOESSMANN,	*Analyst.*
HERMANN C. LYTHGOE,	*Assistant Analyst.*
JOHN F. MCCAFFREY,	*Inspector.*
JOHN H. TERRY,	*Inspector.*
HORACE F. DAVIS,	*Inspector.*

The number of samples of food and drugs examined during the year is shown in the accompanying table, together with a condensed summary of the work done since and including the year 1883. The full table published in earlier years is omitted in the present report, the following condensed table being substituted for the sake of brevity: —

Number of samples of milk examined,	6,256
Number of samples above standard,	4,307
Number of samples below standard,	1,949
Percentage of adulteration or deficiency,	31.1

Number of samples of other kinds of food examined (not milk),	3,090
Number of samples above standard,	2,538
Number of samples below standard,	552
Percentage of adulteration,	17.8

Number of samples of drugs examined,	1,124
Number of samples of good quality,	636
Number of samples adulterated (as defined by the statutes),	488
Percentage of adulteration,	43.4

Total number of samples of food and drugs examined,	10,470
Total number found to be of good quality,	7,481
Total number found not conforming to the statutes,	2,989
Percentage of adulteration,	28.1

FOOD AND DRUG INSPECTION (1883–1902).

SUMMARY.	YEARS.		
	1901.	**1902.**	Total **1883-1902.**
Number of samples of milk examined,	6,247	6,256	76,119
Number of samples above standard,	4,490	4,307	48,161
Number of samples below standard,	1,757	1,949	27,958
Percentage of adulteration,	28.1	31.1	36.7
Number of samples of other kinds of food examined (not milk),	3,120	3,090	48,935
Number of samples of good quality,	2,530	2,538	39,812
Number of samples adulterated, as defined by the statutes,	590	552	9,123
Percentage of adulteration,	18.9	17.8	18.6
Number of samples of drugs examined,	958	1,124	13,255
Number of samples of good quality,	468	636	8,120
Number of samples adulterated, as defined by the statutes,	490	488	5,135
Percentage of adulteration,	51.3	43.4	38.7
Total examinations of food and drugs,	10,325	10,470	138,309
Total examinations of good quality,	7,488	7,481	96,093
Total examinations not conforming to the statutes,	2,837	2,989	42,216
Percentage of adulteration,	27.5	28.1	30.5
Expense of collection, examination and prosecution,	$12,341 38	$11,700 23	$196,989 52
Expense of collection, examination and prosecution, per sample,	1 19	1 12	1 42

From the foregoing table it appears that 10,470 samples of food and drugs were examined during the year ended Sept. 30, 1902, of which number 2,989, or 28.1 per cent., were found not to conform to the legal standard. It has been stated many times in previous reports that this large ratio of adulteration does not represent the proportion of adulteration which exists in the general food supply, but only the percentage which exists in such articles as are collected for examination, these being chiefly the articles which are known by experience to be specially liable to adulteration.

The whole number of samples of food and drugs examined since the beginning of work in 1883 was 138,309, of which 76,119, or more than one-half, as required by the statutes, were samples of milk. The amount expended in the enforcement of the food and drug acts since the beginning of work has been $196,989.52, and the expense per sample $1.42 for the whole time. This expense has been reduced from $2.26 per sample in 1883 to $1.12 in 1902.

In the report of the analyst for 1902 special attention is directed to several summaries, embracing the work of several years. *First.* The experience of the laboratory in the examination of milk for artificial coloring matter shows that this method of adulteration had been used in 343 samples out of 48,519 in all in nine years, or only seven-tenths of 1 per cent. This form of adulteration is usually employed to conceal other methods and give the milk the appearance of a milk of unusually good quality. *Second.* A similar summary is presented relative to the use of preservatives, embracing a period of five years (1898–1902). The number of samples examined for this purpose was 9,257, of which number 376, or 4 per cent., contained preservatives of some sort. In several of the recent reports of the Board the results of examination of samples of condensed milk have been published, and in consequence of this publication considerable correspondence has been had with parties who manufacture brands which, upon analysis, proved to be of inferior quality. Since the fat or cream is the most valuable constituent of the milk, it is convenient to assume the fat contents as a measure of quality. Reference to reports of the Board show that the amount of fat in condensed milk varies from as low as 5 per cent. to as much as 12 per cent. or more. Unfortunately, there is no legal standard of condensed milk. So long, however, as many brands are found to contain as much as 10 to 12 per cent. of cream, representing from 3½ to 5 per cent. of cream in the original milk from which the condensed milk is made, it would appear entirely reasonable to expect that condensed milk should contain as much as 9 per cent. of cream, although it might be difficult to maintain a complaint at court, in which the cream fell below that percentage, in the absence of such standard.

One of the excuses of food adulterations is that it is necessary to add certain substances to render such articles salable. The substances added, however, are invariably of inferior quality or price. Upon the label of certain brands of honey it is stated that sugar has been added to prevent crystallization. It is quite possible, however, to find good honey without this addition. So, also, with certain spices, which are ground entire with the shells or hulls; a reasonable percentage of such shells or hulls may be present, but a large excess indicates adulteration, either intentional or otherwise. The amount of adulteration in spices and in coffee compared with that which existed twenty years ago is very small, the change in this class of food having been very largely wrought by the action of the law.

In the twenty-eighth annual report of the Board (1896) a list of certain proprietary medicines containing alcohol, and certain other proprietary articles containing poisonous and injurious ingredients, was published by the Board. The information thus published has been sought for from very many sources, and the edition was exhausted in a few years. Hence it has seemed desirable to republish the information which formed part of that report in a new edition, with such additions of new material of the same character as have been made since that time.

The addition of the work of analyzing intoxicating liquors to the work of this department by a statute of 1902 has materially increased the work of the office and rendered an additional appropriation necessary for this special work. An account of the work performed in the laboratory in this direction is appended to the analyst's report.

The following list contains the names of the cities and towns to which notices were sent on account of adulterated articles and the number sent to each: —

Cities and Towns to which Notices were sent on Account of Adulterated Milk in 1902.

Attleborough,	8	New Bedford,	6
Beverly,	9	Newton,	15
Boston,	4	Peabody,	1
Brockton,	5	Pittsfield,	1
Brookline,	1	Plymouth,	1
Cambridge,	15	Provincetown,	3
Chelsea,	30	Quincy,	4
Clinton,	2	Revere,	12
Dedham,	2	Salem,	7
Everett,	10	Somerville,	17
Fall River,	14	Springfield,	1
Fitchburg,	7	Taunton,	1
Gloucester,	17	Waltham,	3
Haverhill,	9	Ware,	1
Holyoke,	1	Wareham,	1
Hudson,	1	Watertown,	10
Hyde Park,	9	Westborough,	1
Ipswich,	1	Westfield,	1
Lawrence,	4	Winchester,	1
Leominster,	2	Winthrop,	2
Lowell,	5	Woburn,	1
Malden,	3	Worcester,	10
Marlborough,	2		
Medford,	2	Total,	264
Milford,	1		

Cities and Towns to which Notices were sent on Account of Adulterated Articles of Food Other than Milk.

Attleborough,	1
Ayer,	1
Blackstone,	1
Boston,	26
Brockton,	2
Cambridge,	4
Everett,	1
Fall River,	16
Fitchburg,	5
Holyoke,	5
Hyde Park,	1
Ipswich,	1
Lawrence,	10
Leominster,	2
Lowell,	8
Malden,	3
Milford,	1
New Bedford,	13
Newburyport,	2
Quincy,	2
Revere,	2
Salem,	3
Somerville,	1
Stoughton,	2
Wareham,	2
Westborough,	1
Weymouth,	3
Worcester,	8
Total,	127

Cities and Towns to which Notices were sent on Account of Adulterated Drugs.

Attleborough,	2
Ayer,	2
Boston,	75
Brockton,	1
Cambridge,	1
Chelsea,	1
Clinton,	1
Dedham,	1
Everett,	1
Fall River,	6
Fitchburg,	4
Haverhill,	2
Holyoke,	1
Hyde Park,	1
Lawrence,	4
Lowell,	5
Lynn,	3
Malden,	1
Maynard,	1
Melrose,	2
Milford,	1
Needham,	1
New Bedford,	3
Northampton,	4
Pepperell,	1
Salem,	4
Somerville,	3
Springfield,	1
Stoneham,	4
Taunton,	1
Waltham,	1
Ware,	1
Wareham,	1
Watertown,	3
Worcester,	1
Total,	145

PROSECUTIONS.

The following condensed summary is presented in accordance with the custom which has been followed in the reports of the past ten years.

The following table presents the same figures, with the addition of the data relating to the prosecutions conducted during the year ended Sept. 30, 1902: —

Number of Complaints entered in Court.

YEAR.	Food and Other Articles (not including Milk).	Drugs.	Milk.	Total.	Convictions.	Fines imposed.
1883, . . .	–	5	4	9	8	–*
1884, . . .	2	1	45	48	44	–*
1885,† . . .	50	1	68	119	103	–*
1886,‡ . . .	10	–	10	20	19	–*
1887, . . .	30	–	34	64	60	–*
1888, . . .	22	–	43	65	61	$2,042 00
1889, . . .	74	–	66	140	124	3,889 00
1890, . . .	78	–	24	102	96	3,919 00
1891, . . .	96	5	49	150	135	2,668 00
1892, . . .	52	12	72	136	123	3,661 70
1893, . . .	26	3	67	96	92	2,476 00
1894, . . .	14	–	76	90	77	2,625 00
1895, . . .	13	11	68	92	86	2,895 30
1896, . . .	7	–	68	75	74	2,812 20
1897, . . .	13	1	51	65	64	2,756 60
1898, . . .	10	–	54	64	62	2,060 98
1899, . . .	19	2	26	47	45	1,432 66
1900, . . .	45	5	44	94	89	1,890 70
1901, . . .	30	–	65	95	90	1,874 70
1902, . . .	25	3	48	76	74	2,617 98
Total, . .	616	49	982	1,647	1,526	$38,621 82

* No record kept. † To May 1, 1886. ‡ Four months only.

Ratio of convictions to complaints, 92.6 per cent.

NOTE. — All complaints entered before May 1, 1886, were under the direction of the Board of Health, Lunacy and Charity, and all after that date were under the direction of the State Board of Health.

The number of prosecutions made against offenders during the year was 76, and the number of convictions 74.

The following report was transmitted to the Legislature Jan. 7., 1903, in compliance with the terms of the statute, section 7, chapter 75, Revised Laws: —

Office of the State Board of Health,
State House, Boston, Jan. 7, 1903.

To the Honorable Senate and House of Representatives of the Commonwealth of Massachusetts in General Court assembled.

The following summary is made in compliance with the provisions of chapter 75 of the Revised Laws, requiring the State Board of Health to "report annually to the Legislature the number of prosecutions made under the provisions of the food and drug acts, and an itemized account of all money expended in carrying out the provisions thereof."

The whole number of prosecutions made by authority of the Board against offenders, under the provisions of the food and drug acts, for the year ended Sept. 30, 1902, was 76.

The cities and towns in which the articles were sold, and in respect to which complaints were entered in court, the character of the articles found to be adulterated or fraudulently sold, the dates of the trials, and their results, are presented in the following list: —

Milk and Milk Products.

For Fraudulent Sales of Milk.

Place.	Date.	Result.
Lowell,	Oct. 30, 1901,	Convicted.
Lowell,	Oct. 30, 1901,	Convicted.
Lowell,	Oct. 30, 1901,	Convicted.
Lowell,	Jan. 16, 1902,	Convicted.
Lowell,	Jan. 21, 1902,	Convicted.
Lowell,	Jan. 21, 1902,	Convicted.
Lowell,	April 17, 1902,	Convicted.
Lowell,	April 17, 1902,	Convicted.
Lowell,	April 17, 1902,	Convicted.
Lowell,	April 17, 1902,	Convicted.
Lowell,	April 17, 1902,	Convicted.
Lowell,	June 16, 1902,	Convicted.
Lowell,	June 16, 1902,	Convicted.
Lowell,	June 16, 1902,	Convicted.
Fall River,	July 24, 1902,	Convicted.
Fall River,	July 24, 1902,	Convicted.
Fall River,	July 31, 1902,	Convicted.
Worcester,	April 29, 1902,	Convicted.
Worcester,	April 29, 1902,	Convicted.
Salem,	July 11, 1902,	Convicted.
Salem,	July 11, 1902,	Convicted.
Beverly,	Aug. 26, 1902,	Convicted.
Beverly,	Aug. 26, 1902,	Convicted.
Somerville,	Aug. 9, 1902,	Convicted.
Marlborough,	April 1, 1902,	Convicted.
Marlborough,	April 1, 1902,	Convicted.

MILK AND MILK PRODUCTS — Concluded.

For Fraudulent Sales of Milk — Concluded.

PLACE.	DATE.	RESULT.
Chelsea,	June 6, 1902,	Convicted.
Chelsea,	June 6, 1902,	Discharged.
Newton,	Nov. 20, 1902,	Convicted.
Quincy,	Jan. 31, 1902,	Convicted.
Peabody,	Aug. 30, 1902,	Convicted.
Peabody,	Aug. 30, 1902,	Convicted.
Peabody,	Sept. 6, 1902,	Convicted.
Peabody,	Sept. 6, 1902,	Convicted.
Acton,	Oct. 31, 1901,	Convicted.
Middleton,	Oct. 24, 1901,	Convicted.
Middleton,	Oct. 24, 1901,	Convicted.
Townsend,	Dec. 26, 1901,	Convicted.
Dover,	Feb. 21, 1902,	Convicted.
Needham,	March 26, 1902,	Convicted.
Weston,	March 19, 1902,	Convicted.
Clinton,	April 26, 1902,	Convicted.
Bedford,	May 13, 1902,	Convicted.
Palmer,	May 22, 1902,	Convicted.
Westborough,	May 26, 1902,	Convicted.
Wareham,	Sept. 2, 1902,	Convicted.
Milford,	Sept. 9, 1902,	Convicted.
Dedham,	Sept. 10, 1902,	Convicted.

Butter and Oleomargarine.

PLACE.	DATE.	RESULT.
Fall River,	Nov. 23, 1901,	Convicted.
Worcester,	June 11, 1902,	Convicted.
Worcester,	June 11, 1902,	Convicted.
Worcester,	Aug. 28, 1902,	Convicted.
New Bedford,	Sept. 3, 1902,	Convicted.
New Bedford,	Jan. 28, 1902,	Convicted.
New Bedford,	March 5, 1902,	Convicted.
Fitchburg,	April 3, 1902,	Convicted.
Fitchburg,	April 3, 1902,	Convicted.
Waltham,	May 1, 1902,	Convicted.
Waltham,	May 5, 1902,	Convicted.
Springfield,	July 24, 1902,	Convicted.
Salem,	Aug. 11, 1902,	Discharged.
Salem,	Aug. 14, 1902,	Convicted.
Leominster,	May 28, 1902,	Convicted.

MOLASSES.

PLACE.	DATE.	RESULT.
New Bedford,	Feb. 12, 1902,	Convicted.
Blackstone,	Feb. 5, 1902,	Convicted.

CIDER VINEGAR.

PLACE.	DATE.	RESULT.
New Bedford,	March 12, 1902,	Convicted.
New Bedford,	March 12, 1902,	Convicted.

PEPPER.

New Bedford,	Nov. 1, 1901,	Convicted.

MAPLE SYRUP.

Fitchburg,	May 16, 1902,	Convicted.

DRUGS.

Phosphate of Soda.

New Bedford,	Feb. 19, 1902,	Convicted.
New Bedford,	Feb. 19, 1902,	Convicted.

Quinine Pills.

Boston,	March 15, 1902,	Convicted.

Cases entered in court but not under the food and drug acts: —

For Sale of Alcohol not of Standard Quality.

Brockton,	Aug. 12, 1902,	Convicted.
Brockton,	Aug. 12, 1902,	Convicted.
Brockton,	Aug. 12, 1902,	Convicted.

For Sale of Cloth containing Arsenic in Excess of the Prescribed Legal Limit.

(*Revised Laws, chap. 213, § 8.*)

Boston,	Sept. 19, 1902,	Convicted.

SUMMARY.

The number of complaints entered by the State Board of Health during the year ended Sept. 30, 1902, in the courts of the Commonwealth, against parties for violation of the statutes relating to food and drug inspection, and other allied acts, was 76. In 74, or 97.4 per cent., of these the parties were convicted, and 2 were discharged.

Of the whole number, 63 were for violation of the statutes relating to the adulteration of milk and milk products, and of this number 61 resulted in conviction. The greater number of these were for violation of the statutes providing that milk offered for sale shall be of good standard quality. In 5 of the foregoing cases the complaints were made on account of milk containing coloring matter, and in 4, on account of the presence of formaldehyde, which had been added for the purpose of preserving the milk.

When coloring matter is added the milk is usually otherwise adulterated by the addition of water, or by the abstraction of cream.

The other articles of food with reference to which complaints were made were as follows: molasses, 2 cases; cider vinegar, 2 cases; pepper, 1 case; maple syrup, 1 case.

The complaints relating to drugs were for sales of phosphate of soda containing arsenic, and quinine pills which were considerably below the weight indicated upon the label.

The whole number of samples of food and drugs examined in this department since the beginning of work in 1883 was 138,310, and the number of complaints entered in court was 1,647.

The average cost per sample, for collection, analysis and other work, has been reduced from $2.26 per sample in 1883 to $1.12 in 1902.

The following list presents the total solids in each of the samples of milk upon which complaints were founded, so far as records of the same were kept: —

7.50
7.92
8.50
8.80
8.80
8.88
9.00
9.46
9.46
9.63
9.84
9.94
10.09
10.27
10.27
10.30
10.40
10.42
10.53
10.75
10.76
10.79
10.80
10.87
10.91
10.93
10.97
11.07
11.15
11.15
11.27
11.33
11.34
11.40
11.44
11.46
11.60
11.66

The total number of samples of food and drugs examined during the year was as follows: —

Milk,	6,256
Other articles of food, including 207 samples of butter and cheese,	3,090
Drugs,	1,124
Total,	10,470

Total expense of collection, examination and prosecution,	$11,700 23
Average expense per sample collected,	1 12

In addition to the foregoing, there were also examined 29 samples of wall papers and fabrics, under the act relating to arsenic (chapter 213, section 8, Revised Laws). Of these, 9 samples contained arsenic beyond the limit defined by the statute.

Under the act requiring the Board to assume the duty of liquor inspection (chapter 110, Acts of 1902), there were also examined 107 samples of liquors, which were submitted to the Board for inspection.

FINES.

The amount of fines paid into the treasuries of counties, cities and towns, under the provisions of the general and special acts relating to food and drugs and other articles, was as follows: —

Fines paid for violation of the acts relating to milk and milk products upon cases entered during the year ended Sept. 30, 1902, .	$1,730 98
Under other laws relating to food, and other articles liable to inspection, ...	887 00
Total, ...	$2,617 98

The whole amount of fines imposed since the beginning of the enforcement of the acts relating to food and drug inspection, to Sept. 30, 1902, was $39,621.82.

EXPENDITURES

Under the Provisions of the Food and Drug Acts during the Year ended Sept. 30, 1902.

	FOR THE ENFORCEMENT OF THE STATUTES RELATING TO FOOD AND DRUG INSPECTION.	
	Relative to Milk and Milk Products.	Relative to Other Kinds of Food and Drugs.
Salaries of analysts, ...	$2,734 01	$1,822 65
Salaries of inspectors, ...	2,772 00	1,848 00
Travelling expenses and purchase of samples, .	1,180 08	786 72
Apparatus and chemicals, ...	167 84	111 90
Printing, ...	15 10	10 06
Services (cleaning laboratory), ...	66 65	37 35
Express and postage, ...	–	7 08
Sundry laboratory expenses, ...	47 51	31 68
Books, ...	27 36	18 24
Extra services (stenographer), ...	9 60	6 40
	$7,020 15	$4,680 08
		7,020 15
Total, ...	. . .	$11,700 23

SAMUEL W. ABBOTT, *Secretary.*

REPORT OF THE ANALYST.

By Albert E. Leach.

REPORT OF THE ANALYST.

By Albert E. Leach.

Dr. S. W. Abbott, *Secretary of the State Board of Health.*

Dear Sir: — I herewith submit my report on the analyses of food and drugs for the year ending Sept. 30, 1902.

The character of the samples submitted for analysis varies but little from year to year. This is largely due to the fact that only the suspected varieties are as a rule examined, long experience having shown the particular kinds, both of foods and of drugs, most liable to adulteration. New adulterants are, however, from time to time encountered, and more skill is now shown than ever before in the preparation of fraudulent brands.

Milk.

In accordance with the custom of the past nineteen years in this department, the percentage of total solids in all the samples collected has been determined. In the earlier years of milk inspection, when fewer samples were collected, all were also examined for fat. In recent years it has been found sufficient to make a determination of fat in such samples only as have been found below 12 per cent. in solids. Methods employed in this laboratory for the analysis of milk, including the detection of colors and preservatives, have been given in full in the analyst's reports for the last four years.

During the present year a new form of milk container has been adopted for the use of the inspectors in collecting samples. This consists of a wide-mouthed, cylindrical, eight-ounce bottle of flint glass, about five inches in height, fitted with a pure rubber stopper and having a square ground panel on the side, in which the number of the sample may be conveniently written, thus doing away with the use of tags and adhesive labels.

The usual statistics showing the geographical distribution of milk samples collected and examined during the year, with the results of the analysis, are summarized as follows: —

Milk from Cities.

CITIES.	Number above Standard.	Number below Standard.	Total Samples collected.	Per Cent. below Standard.	Total Solids in Lowest Sample.	Number of Skimmed Samples.	Number of Samples colored with Annatto.	Number of Samples colored with Aniline Orange.	Number of Samples preserved with Formaldehyde.	Number of Samples preserved with Boric Acid.
Boston, ...	171	67	238	28.1	10.13	-	-	-	-	-
Brockton, . . .	116	42	158	27.2	11.00	-	-	-	-	-
Cambridge, . . .	174	153	327	46.8	10.60	-	-	-	-	-
Chelsea, ...	172	151	323	46.6	8.28	-	-	-	-	2
Everett, ...	128	60	188	31.9	10.20	1	-	-	1	-
Fall River, . . .	73	28	101	27.9	11.12	-	-	-	8	-
Fitchburg, . . .	87	24	111	21.8	8.40	4	-	-	-	-
Gloucester, . . .	175	77	252	31.5	9.47	-	3	-	-	-
Haverhill, . . .	133	46	179	25.6	10.60	-	-	-	-	-
Lawrence, . . .	129	95	224	42.4	8.80	6	-	-	-	-
Lowell, ...	75	89	164	54.3	9.20	3	-	9	-	-
Lynn, ...	9	6	15	40.0	11.55	-	-	-	-	-
Malden, ...	133	59	192	35.4	10.89	-	-	-	-	-
Marlborough, . .	39	13	52	25.0	9.40	2	-	-	-	-
Melrose, . . .	7	8	15	53.3	10.00	-	-	-	-	-
Medford, . . .	64	42	106	39.6	11.27	-	-	-	-	-
New Bedford, . .	92	49	141	34.6	9.32	2	-	-	2	-
Newburyport, . .	120	20	140	14.3	11.13	-	-	-	-	-
Newton, . . .	118	36	154	23.3	8.50	1	-	-	-	-
Quincy, ...	62	24	86	27.9	9.26	-	-	-	-	-
Salem, ...	139	49	188	26.0	10.00	-	-	-	8	-
Somerville, . . .	231	158	389	40.6	10.23	3	-	-	-	4
Taunton, . . .	59	8	67	11.9	8.87	2	-	-	-	-
Waltham, . . .	75	39	114	34.1	9.87	-	-	-	-	-
Woburn, . . .	25	35	60	58.3	8.79	-	-	-	-	-
Worcester, . . .	226	71	297	23.9	7.50	2	-	-	-	-
Summary, . .	2,836	1,445	4,281	33.7	7.50	26	3	9	19	6

Milk from Towns.

TOWNS.	Number above Standard.	Number below Standard.	Total Samples collected.	Per Cent. below Standard.	Total Solids in Lowest Sample.	Number of Skimmed Samples.	Number of Samples colored with Annatto.	Number of Samples colored with Aniline Orange.	Number of Samples preserved with Formaldehyde.	Number of Samples preserved with Boric Acid.
Attleborough, . .	94	35	129	26.9	9.83	6	–	1	–	5
Arlington, . . .	36	10	46	21.8	11.47	–	–	–	2	–
Beverly, . . .	18	20	38	52.6	10.38	–	–	1	1	–
Brookline, . . .	110	22	132	16.7	11.60	–	–	–	–	–
Clinton, ...	25	10	35	28.6	9.17	3	–	–	–	–
Dedham, . . .	77	15	92	16.2	11.43	–	–	–	–	–
Framingham, . .	10	–	10	0.0	12.40	–	–	–	–	–
Hudson, ...	7	3	10	30.0	12.20	–	–	–	–	–
Hyde Park, . . .	67	28	95	29.4	10.40	–	–	–	–	–
Ipswich, . . .	9	8	17	41.2	11.07	–	–	–	–	–
Leominster, . . .	23	6	29	20.7	11.66	2	–	–	–	–
Manchester, . . .	10	1	11	9.9	10.69	–	–	–	2	–
Middleton, . . .	–	3	3	100.0	11.63	–	–	–	3	–
Milford, ...	76	3	79	3.8	12.50	–	–	–	–	–
Natick, ...	17	1	18	5.6	10.44	–	–	–	–	–
Peabody, . . .	44	12	56	18.2	10.60	–	–	2	2	–
Plymouth, . . .	14	–	14	0.0	12.50	–	–	–	–	–
Provincetown, . .	43	2	45	4.4	10.80	–	–	–	–	3
Revere, ...	93	55	148	37.1	7.87	–	–	–	–	–
Salisbury, . . .	15	–	15	0.0	12.51	–	–	–	–	–
Stoneham, . . .	12	3	15	20.0	10.92	2	–	–	–	–
Stoughton, . . .	54	20	74	27.1	11.64	–	–	–	–	–
Swampscott, . . .	10	–	10	0.0	12.18	–	–	–	–	–
Watertown, . . .	50	40	90	44.4	9.29	–	–	–	–	–
Westborough, . .	24	2	26	7.7	12.20	–	–	–	–	–
Weymouth, . . .	20	3	23	13.0	12.02	–	–	–	–	–
Whitman, . . .	14	–	14	0.0	12.65	–	–	–	–	–
Winchester, . . .	–	4	4	100.0	10.71	–	–	–	–	–
Wareham, . . .	20	5	25	20.0	10.53	–	–	–	–	–
Winthrop, . . .	54	15	69	21.7	11.53	–	–	–	–	–
Summary, . .	1,046	326	1,372	23.8	7.87	13	–	4	10	8

Milk from Suspected Producers.

LOCALITY.	Number above Standard.	Number below Standard.	Total Samples collected.	Per Cent. below Standard.	Total Solids in Lowest Sample.
Acton,	–	19	19	100.0	9.63
Bedford,	5	4	9	44.4	8.80
Boylston,	–	15	15	100.0	7.72
Concord,	4	10	14	71.4	11.27
Dover,	–	8	8	100.0	10.87
Holliston,	–	7	7	100.0	9.32
Leominster,	6	–	6	0.0	12.49
Needham,	8	26	34	76.4	9.84
Norwood,	17	3	20	15.0	11.74
Roslindale,	8	–	8	0.0	12.00
Sudbury,	14	–	14	0.0	12.27
Townsend,	6	4	10	40.0	10.79
Wayland,	5	3	8	37.5	12.87
Westborough,	–	15	15	100.0	7.92
Warren,	–	6	6	100.0	10.97
Weston,	1	19	20	95.0	10.00
Westwood,	–	4	4	100.0	12.32
Summary,	74	143	217	65.9	7.72

Summary of Milk Statistics.

	Number above Standard.	Number below Standard.	Total Samples collected.	Per Cent. below Standard.	Total Solids in Lowest Sample.	Number of Skimmed Samples.	Number of Samples colored with Annatto.	Number of Samples colored with Aniline Orange.	Number of Samples preserved with Formaldehyde.	Number of Samples preserved with Boric Acid.
Cities,	2,836	1,445	4,281	33.7	7.50	26	3	9	19	6
Towns,	1,046	326	1,372	23.8	7.87	13	–	4	10	8
Suspected producers,	74	143	217	65.9	7.72	–	–	–	–	–
Summary,	3,956	1,914	5,870	32.6	7.72	39	3	13	29	14

The following table shows the character of the milk by months, being practically a summary of the twelve monthly reports previously presented to the Board: —

Quality of Milk by Months.

	October.	November.	December.	January.	February.	March.	April.	May.	June.	July.	August.	September.	Totals.
Number having more than 15 per cent. of total solids,	10	30	27	25	11	15	14	5	17	17	14	7	192
Number having between 14 and 15 per cent. of total solids,	54	65	57	56	30	35	31	26	35	23	30	24	466
Number having between 13 and 14 per cent. of total solids,	175	231	176	190	136	164	135	137	156	103	96	112	1,811
Number having between 12 and 13 per cent. of total solids,	240	133	141	184	203	223	249	215	277	235	243	247	2,600
Number having between 11 and 12 per cent. of total solids,	66	18	20	30	42	43	53	59	47	54	74	43	549
Number having between 10 and 11 per cent. of total solids,	13	15	10	6	14	30	7	19	10	10	13	16	222
Number having between 9 and 10 per cent. of total solids,	7	4	4	–	3	6	14	11	5	2	11	9	76
Number having between 8 and 9 per cent. of total solids,	1	1	–	–	–	2	3	8	–	1	1	1	18
Number having less than 8 per cent. of total solids,	–	–	–	–	–	2	1	1	–	1	–	–	5
Number of samples of skimmed milk above the standard,	–	6	–	1	–	5	3	2	2	–	1	1	21
Number of samples of skimmed milk below the standard,	3	1	–	1	4	9	10	–	3	–	2	4	37

The number of samples of artificially colored milk (17) collected during the present year is considerably less than for any year since 1894. Samples of colored milk were found in Gloucester, Lowell, Attleborough, Clinton and Leominster, all being below the standard.

Milk with added preservatives was collected in Chelsea, Everett, New Bedford, Salem, Somerville, Arlington, Beverly, Manchester, Middleton and Peabody. Samples of colored milk are usually found to be below the standard, it being deemed necessary to add the color in order to conceal evidence of watering. The reverse is more often true with regard to preservatives, as shown by the fact that out of 43 samples of milk containing preservatives 31 were above the standard.

The following table shows the character and extent of artificial colors used in Massachusetts during the last nine years: —

Artificial Color in Milk.

YEAR.	Number of Samples analyzed.	Number of Colored Samples.	Number containing Annatto.	Number containing Orange Aniline.	Number containing Caramel.
1894,	3,551	16	16	–	–
1895,	3,794	38	34	4	–
1896,	4,484	45	39	6	–
1897,	6,046	54	50	4	–
1898,	6,247	37	29	2	6
1899,	6,186	23	23	–	–
1900,	6,232	67	20	43	4
1901,	6,109	46	15	31	–
1902,	5,870	17	3	14	–
Totals,	48,519	343	229	104	10

Artificial coloring in milk is usually apparent to the practised eye, especially after the cream has risen, by reason of the fact that, unlike the natural color of milk, it is not confined to the fat, but is distributed through the entire mass. This is more readily evident when glass bottles are used as containers. Thus the observing analyst can, in many cases, detect suspicious samples during the process of analysis for total solids, reserving them for subsequent analysis for color. Unlike added color, there is nothing in the physical appearance of milk to suggest the presence of preservatives, nor are they rendered apparent to the taste or smell, if skilfully used. For this reason, and on account of the increased tendency of late years to use preservatives, especially during the summer season, it has been our practice during the months of June, July, August and September to examine all the samples of milk collected for the presence of the commonly used preservatives, namely, formaldehyde, boric acid and sodium carbonate.

The following table shows in a summarized form the extent to which these preservatives have been found in milk examined during the summer seasons of the past five years: —

Preservatives in Milk.

YEAR.	Samples examined.	Number containing Formaldehyde.	Per Cent containing Formaldehyde.	Number containing Boric Acid.	Per Cent. containing Boric Acid.	Number containing Carbonate.	Total containing Preservative
1898, . .	1,046	26	2.5	11	1.0	4	41
1899, . .	2,105	55	2.6	13	0.6	3	71
1900, . .	2,018	61	3.0	6	0.3	-	67
1901, . .	2,154	42	1.9	12	0.5	-	54
1902, . .	1,934	29	1.5	14	0.7	-	43
Totals, .	9,257	213	2.3	56	0.6	7	376

As a possible clue to the presence of coloring matter as well as preservatives in milk, information given by the inspector at the time the samples are handed to the analyst may frequently prove helpful. For instance, there are certain localities in which the use of color or preservative seems to be more prevalent than elsewhere, so that a hint from the inspector warning the analyst to look for a particular form of adulterant known to be common to the locality from which the milk has been collected is often of assistance.

Even in the winter months the analyst is on the lookout for preservatives in such suspected samples, and should make examination for them. Formaldehyde and boric acid, by reason of their cheapness and efficiency, excel all other antiseptics as milk preservatives, and are consequently, of all others, the most used for this purpose. If there is still reason to suspect the presence of a preservative in milk after tests have proved the absence of the above commonly used preservatives, benzoic and salicylic acids should be looked for, although they are not considered ideal milk preservatives. Indeed, in the case of salicylic acid, a distinct sweetish taste is imparted to the milk containing it, especially after standing for some time. In order to detect these preservatives the following methods are employed.

Benzoic Acid. — Add 5 cubic centimeters of dilute hydrochloric acid to 50 cubic centimeters of the milk in a flask and shake to curdle. Then add 150 cubic centimeters of ether, cork the flask and shake well. Break up the emulsion which forms by aid of a centrifuge, or, if the latter is not available, extract the curdled milk by gently shaking with successive portions of ether, avoiding the formation of an emulsion.* Transfer the ether extract (evaporated to small volume, if large in bulk) to a separatory funnel, and separate the benzoic acid from the fat by shaking out with dilute ammonia, which takes out the former as ammonium benzoate. Evaporate the ammonia solution in a dish over the water bath till all free ammonia has disappeared, but before getting to dryness add a few drops of ferric chloride reagent. The characteristic flesh-colored precipitate indicates benzoic acid. Care should be taken not to add the ferric chloride till all the ammonia has been driven off, otherwise a precipitate of ferric hydrate is formed.

Salicylic Acid. — Proceed exactly as directed for benzoic acid. On applying the ferric chloride to the solution after evaporation of the ammonia, the well-known violet color indicates salicylic acid when present.

Erratum from the 1901 report for the method of determining milk sugar, on page 443, line 16, for "200" read "100."

Condensed Milk.

Twenty-three new brands of condensed milk have been examined during the year, and 40 brands the full analyses of which have been given in past reports. Six of these brands are shown on analysis to have been prepared from skimmed milk, being decidedly deficient in fat. We have adopted the custom of making full analysis only of the new brands, while the old ones are simply submitted to an examination for fat and ash. Full methods for the analysis of condensed milk were given in the analyst's previous reports. A new method for computing the fat in the original milk has recently been adopted, by which the calculation may be made without a complete analysis of the sample, by simply determining the fat and ash.

Assuming .70 per cent. as the ash of pure milk, the factor representing the "number of times condensed" is found by dividing the ash of the condensed milk by .7. The "fat in the original milk" as thus calculated is of course an arbitrary factor, and is useful only in deciding whether or not skimmed milk has been used in preparing the sample. By assuming the highest reasonable figure for the ash of natural milk, it is readily seen that the highest result is obtained for the fat in the original milk, and hence the benefit of any doubt is given to the manufacturer.

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* A volume of ether largely in excess over that of the curdled milk has been found to be less apt to form an obstinate emulsion.

The ash of the condensed milk sample is conveniently obtained by evaporating to dryness 12.5 cubic centimeters of the 40 per cent. aqueous solution of the sample which forms the basis of the various determinations, this volume corresponding to 5 grams of the sample. The residue is then incinerated in the muffle, cooled and weighed. If the fat in the original milk as above calculated is found to be much below 3 per cent., there is evidence to show that skimmed milk has been used. This method of procedure is considered more accurate than that hitherto adopted for calculating the fat in the original milk, since the milk ash is a more constant factor than the percentage of solids not fat on which the old method was based. In the case of cheese, it is safe to assume that skimmed milk has been used for its preparation when the proteids exceed the fat. This rule, however, does not apply in the case of condensed milk, as will be seen by reference to the tables.

Condensed Milk.

BRAND.	Total Solids.	Water.	Milk Solids.	Cane Sugar.	Milk Sugar.	Proteids.	Fat.	Ash.	Fat in Original Milk.
Gray's,	72.21	27.79	35.04	37.04	12.81	9.41	11.52	1.43	5.64
Cow Boy,	72.01	27.99	29.73	42.28	9.30	8.08	10.80	1.55	4.32
Success,	71.02	28.98	27.83	43.19	7.98	7.56	10.57	1.72	3.15
Chariot,	70.71	29.29	30.05	40.66	10.30	7.77	10.44	1.54	4.75
Ball,	71.55	28.45	28.15	43.40	9.30	6.84	10.44	1.57	4.65
Eclipse, Jr.,	73.48	26.52	31.32	42.16	12.88	7.01	10.08	1.35	5.22
Express,	71.03	28.03	30.60	40.43	10.15	9.60	9.36	1.49	4.07
Table,	74.45	25.55	29.48	44.97	11.16	7.47	9.27	1.58	4.12
Lennox,	69.29	30.71	27.49	41.80	9.05	7.95	8.82	1.67	3.69
Silver Cord,	71.03	29.97	30.84	40.19	11.17	9.44	8.73	1.50	3.67
Ensign,	73.83	26.17	28.02	45.81	7.98	9.65	8.64	1.75	3.60
Magnolia,	73.72	26.27	28.23	45.49	8.87	9.05	8.56	1.75	4.04
Moosehead,	71.36	28.64	30.01	41.35	9.75	10.19	8.55	1.52	3.54
Pine Tree,	73.67	26.33	31.55	42.12	10.47	10.95	8.38	1.75	3.35
Defiance,	72.93	27.07	35.97	36.96	13.96	12.12	8.28	1.67	2.75
Pennant,	73.95	26.05	26.72	47.23	9.58	7.81	7.92	1.41	3.96
Up-to-Date,	70.52	29.48	28.21	42.31	8.87	9.86	7.92	1.56	3.53
Connor's,	70.29	29.71	27.96	42.33	7.44	11.03	7.92	1.57	3.44
Dr. Hand's,	73.25	26.75	29.78	43.47	11.16	9.00	7.92	1.70	3.37
Crest,	74.46	25.54	31.46	43.00	11.76	10.25	7.74	1.71	3.17
Stag,	73.00	27.00	28.18	44.82	9.58	9.99	7.56	1.05	3.40
Oxford,	68.61	31.39	32.46	36.15	16.75	7.22	6.84	1.65	2.91
Stag,	73.85	26.15	29.72	44.13	10.15	11.35	6.84	1.58	2.79
Challenge,	73.78	26.22	29.30	44.48	9.58	12.46	5.76	1.50	2.44

Evaporated Cream.

Pet,	27.52	72.48	25.78	1.74	8.99	8.39	6.97	1.43	3.40
Imperial,	-	-	-	-	-	-	12.80	1.38	6.40

Condensed Milk.

BRAND.	Fat.	Ash.	Fat in Original Milk.	BRAND.	Fat.	Ash.	Fat in Original Milk.
	Per Cent.	Per Cent.	Per Cent.		Per Cent.	Per Cent.	Per Cent.
Purity, . .	10.31	1.56	4.62	Dixie, . . .	9.00	-	-
Success, . .	10.26	1.70	4.22	Rustic, . . .	8.82	1.38	4.48
Vermont, . .	10.17	1.43	4.98	Wind Mill, . .	8.82	1.42	4.38
Tip Top, . .	9.90	1.49	4.65	Dirigo, . . .	8.82	1.47	4.20
Nestle's Swiss, .	9.72	1.44	4.70	Challenge, . .	8.82	1.57	3.93
Rose, . . .	9.72	1.95	3.47	Ruby, . . .	8.68	1.40	4.38
Tip Top, . .	9.63	-	-	Dime, . . .	8.42	1.52	3.83
Liberty, . .	9.54	1.48	4.52	Standard, . .	8.37	1.39	4.21
Defiance, . .	9.54	1.79	3.47	Rustic, . . .	8.28	1.48	3.94
Beacon, . .	9.36	1.60	4.06	Dairy, . . .	8.28	1.65	3.72
Dixie, . . .	9.33	-	-	Connor, . .	8.10	1.57	3.60
Cow Boy, . .	9.27	1.60	4.07	Jersey, . . .	8.10	1.47	3.85
Windmill, . .	9.18	1.62	3.95	Eclipse Junior, .	8.10	1.67	3.38
Eagle, . . .	9.18	1.63	3.95	Grandmother's, .	7.74	1.74	3.09
Tip Top, . .	9.18	-	-	Ensign, . . .	7.56	1.57	3.37
Jersey, . .	9.00	1.40	4.50	Vermont, . .	7.38	1.55	3.35
Champlain, . .	9.00	1.50	4.09	Lone Star, . .	7.20	1.74	3.41
J. B. Smith, .	9.00	1.60	3.91	Pennant, . .	7.20	1.66	3.08
Milk Maid, . .	9.00	1.82	3.46	Leader, . . .	6.73	1.73	2.87
Dairy, . . .	9.00	-	-	Vermont, . .	6.66	1.65	2.82

BUTTER.

Out of 165 samples examined, 41 were classed as adulterated. Of these 15 samples were oleomargarine and 26 were renovated butter. Methods for the detection of renovated butter were given quite fully in the analyst's report for last year.

Increased experience with the "foam" test has proved its reliability in distinguishing between pure butter on the one hand and renovated butter or oleomargarine on the other. The "foam" test certainly furnishes conclusive evidence, even though it may not be considered scientific. The writer has found the Waterhouse test to be very reliable as a means for distinguishing between the three products, pure butter, renovated butter and oleomargarine, when carried out in the following manner: —

*The Waterhouse or Milk Test.** — This test is based on the assumption that butter fat, which is in itself exclusively the product of milk, will mingle intimately with milk when added thereto in a melted condition and cooled therein, while oleomargarine, being foreign to milk fat, will, under like conditions, refuse to diffuse itself naturally in milk as a medium. About 50 cubic centimeters of sweet skimmed milk are heated nearly to boiling in a beaker, and from 5 to 10 grams of the sample to be tested are added. The mixture is then stirred, preferably with a small wooden stick, until the fat is melted. The beaker is then placed in a dish of ice-water and the stirring continued till the fat reaches the solidifying point, at which limit, if the sample is oleomargarine, the fat can readily be collected by the stirrer into one lump, but if it is butter it cannot be collected, but remains in a granulated condition, distributed through the milk in small particles. It is not necessary to keep up the stirring through the entire time of cooling, but to begin stirring before the fat starts to solidify, which should require from ten to fifteen minutes after the mixture is placed in the ice-water. This test, if carefully carried out, shows a marked distinction between butter (whether pure or renovated) and oleomargarine. Under certain conditions, as when cooling is too rapid, samples of renovated butter fat will sometimes show a slight tendency to clot together, as in the case of oleomargarine, but to no such extent as the latter. Not only does it identify oleomargarine from butter, but in nearly every case renovated butter can be distinguished from genuine. As a rule, genuine butter fat, even after cooling to the solidifying point, shows the greatest tendency to emulsionize with the milk when stirred, without as a rule adhering to the wooden rod, and is very slow to come to the surface when the stirring is stopped. Renovated butter fat, when stirred in the cooled milk, immediately gathers in a film on the surface of the milk when the stirring is stopped, but without emulsionizing. While it does not clot together like oleomargarine, it tends to adhere slightly to the wooden rod.

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* Parsons, Journal American Chemical Society, 23, 1901, page 200.

Uncolored Oleomargarine. — Since the passing of the act imposing a tax on oleomargarine colored to resemble butter, the attempt has been made by manufacturers to produce a naturally colored oleomargarine with as deep a yellow tint as possible. The result has been that products possessing a much deeper natural color have been made than was formerly thought possible, due largely to various devices on the part of the manufacturer to impart as deep a color as possible in the process of manufacture to the oleo oil, cotton-seed oil and other ingredients used in its preparation. Brands are now in the market that would formerly have been judged artificially colored by their appearance, which, on chemical analysis, do not show the presence of an artificial dye. Palm oil is said to be used for increasing the color.

CHEESE.

Twenty-seven samples were examined, all of which were found to conform to the law.

CHOCOLATE AND COCOA.

Forty-five samples were examined, of which 18 were found to be adulterated with corn, wheat, arrowroot and cocoa shells. The worst sample was found to contain 35 per cent. of wheat.

COFFEE.

Only 2 samples out of 125 examined were found to be adulterated. The adulterants found in both cases were chicory and wheat.

CONFECTIONERY.

The single adulterated sample out of the 31 examined was so classed by reason of containing peppermint made with decomposed oil.

CREAM OF TARTAR.

Three hundred and twenty-six samples were examined, 20 of which were found to be adulterated, the adulterants being, as usual, cornstarch, acid phosphate of lime and calcium sulphate. One of those samples was found to contain no tartrate whatsoever, and consisted entirely of a mixture of starch and acid phosphate. Its acidity was about nine-tenths that of normal cream of tartar.

FLAVORING EXTRACTS.

Lemon Extract. — Sixteen samples of lemon extracts were analyzed, 13 of which were found not to conform to the standard. Many brands are still found in the market containing no oil of lemon whatsoever, while others contain it, but in amounts far below the standard, which is 5 per cent. More of these preparations than formerly are marked with formulæ stating the name and percentage of the ingredients, but these are often found to be misleading or deceptive. The chief trouble is that the alcohol used is too dilute to dissolve the required amount of lemon oil.

The following brands of lemon extract were classed as not being of standard quality through insufficient lemon oil, without a formula stating the correct amount present: —

Lemon Extracts not of Standard Quality.

BRAND.	Manufacturer.	Lemon Oil (Per Cent.).	Alcohol (Per Cent.).	Color.	Formula.
American Standard,	J. F. Morrison, Lowell,	0.0	44.79	-	None.
Climax Compound,	Climax Extract Company, New York.	0.0	27.86	Coal-tar dye.	0.16 per cent. oil.
Compound Extract,	Bell Preserving Company, Boston.	0.0	20.99	Dinitrocresol.	2 per cent. oil.
"Concentrated,"	XLCR Extract Company, Chelsea.	0.0	20.61	Tropæolin.	1 per cent. oil.
Derby "Extra Strength,"	Derby Food Preserving Company.	0.2	52.44	-	None.
Favorite,	Cate & Sullivan, Fall River.	2.3	74.63	-	None.
Harris Pure,	Frank E. Harris, Binghamton, N. Y.	3.3	87.85	-	None.
Kidder's "Concentrated,"	Kidder & Co., Boston,	1.0	66.19	Tropæolin.	None.
Manning's,	L. W. Manning Co., Somerville.	Trace	61.23	Tropæolin.	None.
Miner's,	B. F. Miner, Montague, Mass.	2.3	78.51	-	None.
Standard,	Salem Chemical & Supply Company, Salem.	1.1	-	-	None.
Sterling "Pure Concentrated."	Sterling Extract Company, Cambridgeport.	0.0	23.98	Dinitrocresol.	None.

Vanilla Extract. — Fifteen out of 18 samples examined were found adulterated, either by reason of being purely artificial tinctures of vanillin and not true extracts of the vanilla bean, or because they failed to conform to the formula in cases where there was one. The use of formulæ for this class of goods is on the increase, but in many cases they are not found to conform to the results of our analysis.

Of the vanilla extracts examined, the following brands were found not to be true extracts of the vanilla bean, or to owe their flavoring wholly or in part to coumarin, the principle of the tonka bean, being unaccompanied by a formula explaining the exact facts : —

Vanilla Extracts not of Standard Quality.

BRAND.	Name and Address of Manufacturer.
"True Vanilla Flavoring Extract,"	Beach & Clarridge, Boston.
Climax Compound,	Climax Extract Company, New York.
"Compound,"	American Extract Company, New York.
Derby,	Derby Food Producing Company, Boston.
Gold Seal,	No address.
Lion,	Highland Extract Company, Boston.
Manning,	L. W. Manning & Co., Boston.
Perfection,	No address.
Silver King,	D. L. Shaw, New York.
Victor,	Victor Manufacturing Company, Boston.

Methods for the determination of coumarin and vanillin have been given in full in past reports. Artificial vanilla extracts, by which are meant those not prepared from the vanilla bean, but alcoholic tinctures of artificial vanillin and usually coumarin, are distinguishable from the true extracts in a variety of ways. If a portion of the extract be freed from the alcohol by evaporation, made up to its original volume with water and acidified with acetic acid, in the case of a true extract a reddish brown precipitate of resin will form. Absence of such a resin would indicate an artificial extract. Again, with a true extract of the bean, a copious precipitate should occur on treating the filtrate from the resin with basic lead acetate. Absence of such a precipitate indicates an artificial extract. The character of the resin when submitted to various tests suggested by Hess* furnishes useful clues in deciding the origin of the extract.

Coumarin and vanillin are readily distinguished from each other as follows: an aqueous solution of vanillin is turned green by the addition of a drop or two of ferric chloride, coumarin being unaffected. An aqueous solution of coumarin, unlike vanillin, forms a precipitate when iodine in potassium iodine is added in excess, the precipitate being at first brown and flocculent, and afterwards, on shaking, clotting together to form a dark green curdy mass, leaving the liquid perfectly clear. Crystals of coumarin and vanillin when tolerably pure may be distinguished from each other microscopically as follows: — a few drops of the ether solution of the crystals are poured directly on a slide and allowed to evaporate spontaneously. Vanillin under best conditions crystallizes from ether in long, slender needles, often radiating from central points or forming star-shaped bundles. Coumarin crystals are shorter and thicker than those of vanillin. With polarized light under the microscope, vanillin crystals give a brilliant play of colors between crossed nichols even without the selenite plate, while coumarin crystals without the selenite are almost lacking in colors and show very little play when the selenite is employed. Several repeated crystallizations may be found necessary before the best results are obtained.

HONEY.

Forty-three samples of honey were examined, 15 of which were found to contain one or the other of the usual adulterants, cane-sugar and commercial glucose. One sample was found to contain 26 per cent. of cane-sugar, another 90 per cent. of glucose; a third sample was found artificially colored with tropæolin.

LARD.

Twenty-two samples were examined, of which 4 were found adulterated. These were sold as genuine lard, and consisted of the usual ingredients of compound lard, cotton-seed oil and lard stearine.

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* Journal American Chemical Society, 21 (1899), p. 719.

Maple Sugar and Syrup.

The 6 samples of maple sugar examined were all passed as genuine. Of the 28 samples of syrup, 5 were pronounced adulterated either by an admixture of commercial glucose, or because they were found to consist chiefly of cane sugar other than maple. One sample was examined containing 20 per cent. of commercial glucose.

Molasses.

Thirteen samples were found adulterated out of the 146 analyzed, the adulterant in all cases being commercial glucose. One sample was found with 80 per cent. of this substance.

Spices.

Allspice. — Seven adulterated samples were found, out of 199 examined. The adulterants were wheat and exhausted ginger.

Cassia. — Out of the 215 samples examined, 5 were found to be adulterated. Exhausted ginger and cassia buds were the adulterants.

Cayenne. — Six samples were adulterated out of 66 examined. The worst sample contained 30 per cent. of corn starch and turmeric.

Cloves. — One hundred and ninety-six samples were examined, of which 31 were found to be adulterated. The adulterants found were allspice, nut shells, sawdust, sand and sweepings.

Ginger. — Out of the 246 samples examined, 17 were found to be adulterated. Turmeric, corn starch, buckwheat and allspice were found in the impure samples. The worst sample contained 30 per cent. turmeric, buckwheat and powdered charcoal.

Mace. — Twelve out of the 24 samples examined were adulterated. Corn starch and wild mace furnished the adulterants.

Mustard. — Two hundred and eighty-five samples were analyzed, of which 90 per cent. were impure by reason of containing starch, turmeric, or an excess of mustard hulls. The worst sample contained 60 per cent. of corn starch and turmeric.

Nutmeg. — Seven samples were examined, all of which were pure.

Pepper. — Three hundred and eighty-six samples were examined, 33 of which were adulterated. Materials used as adulterants were pepper shells in excess, olive stones, nut shells, ginger, corn, buckwheat and sawdust.

Tea.

Forty-four samples were examined, all of which were genuine.

Vinegar.

Two hundred and seventy samples of alleged cider vinegar were examined. One hundred and seventy-eight were condemned, either by reason of their being below the standard fixed by law, or as being artificial products sold for cider vinegar. About 100 samples of those classed as adulterated failed to conform to the standard, while 75 samples, though sold as cider vinegar, and though some of them were above the legal standard for solids and acidity, were undoubtedly not the exclusive product of pure apple cider as specified by law. Much attention is now paid to the detection of artificial cider vinegars, with the result that the spurious products are nearly always capable of detection, in spite of the skill of late shown in their manufacture. The following tables show the result of the examination of the two classes of adulterated vinegar: —

Cider Vinegar not of Good Standard Quality.

Acid (Per Cent.)	Solids (Per Cent.).	Polarization in 200 Millimeter Tube.	Lead Acetate.	Acid (Per Cent.).	Solids (Per Cent.).	Polarization in 200 Millimeter Tube.	Lead Acetate.
5.80	1.95	—1.4	Precipitate.	4.40	1.94	—0.3	Precipitate.
5.06	1.85	—0.2	Precipitate.	4.40	1.60	—1.9	Precipitate.
5.02	1.91	-	Precipitate.	4.38	1.95	—1.3	Precipitate.
5.00	1.90	—1.6	Precipitate.	4.36	2.30	—1.1	Precipitate.
5.00	1.40	—1.2	Precipitate.	4.34	2.88	—1.3	Precipitate.
4.92	1.80	—0.7	Precipitate.	4.34	2.15	—1.0	Precipitate.
4.90	1.93	—1.8	Precipitate.	4.34	2.06	—1.7	Precipitate.
4.84	1.80	—1.7	Precipitate.	4.34	1.77	—0.7	Precipitate.
4.80	1.76	—0.6	Precipitate.	4.34	1.60	—0.5	Precipitate.
4.78	1.89	—0.2	Precipitate.	4.32	2.10	—1.6	Precipitate.
4.77	1.94	—1.4	Precipitate.	4.32	2.02	—1.4	Precipitate.
4.74	1.80	—1.1	Precipitate.	4.32	1.94	—0.5	Precipitate.
4.72	1.95	—1.3	Precipitate.	4.30	3.60	—1.5	Precipitate.
4.70	1.91	—2.2	Precipitate.	4.30	2.57	—3.1	Precipitate.
4.70	1.78	—0.8	Precipitate.	4.28	1.85	—0.2	Precipitate.
4.64	1.90	—3.0	Precipitate.	4.28	1.75	—0.6	Precipitate.
4.64	1.28	—0.4	Precipitate.	4.26	2.20	—0.8	Precipitate.
4.63	1.80	—0.9	Precipitate.	4.22	1.50	—1.0	Precipitate.
4.62	1.89	—0.6	Precipitate.	4.21	1.95	—1.3	Precipitate.
4.56	1.97	—0.7	Precipitate.	4.20	2.20	—1.4	Precipitate.
4.56	1.86	—0.3	Precipitate.	4.20	2.20	—1.4	Precipitate.
4.54	1.85	—3.4	Precipitate.	4.20	2.10	—1.3	Precipitate.
4.52	1.98	—1.1	Precipitate.	4.18	1.73	—1.3	Precipitate.
4.52	1.52	—1.7	Precipitate.	4.14	2.40	—0.7	Precipitate.
4.50	1.65	—1.7	Precipitate.	4.12	2.60	—2.3	Precipitate.
4.50	1.12	—2.2	Precipitate.	4.12	2.10	—2.8	Precipitate.
4.49	1.82	-	Precipitate.	4.04	2.43	—4.6	Precipitate.
4.48	2.60	—0.6	Precipitate.	4.00	1.85	—1.0	Precipitate.
4.48	2.23	—1.9	Precipitate.	3.90	2.31	—2.6	Precipitate.
4.48	2.15	—0.6	Precipitate.	3.82	2.13	—1.9	Precipitate.
4.48	2.09	—1.0	Precipitate.	3.76	2.24	—0.5	Precipitate.
4.48	1.82	—3.3	Precipitate.	3.70	1.93	—1.2	Precipitate.
4.48	1.37	—0.6	Precipitate.	3.70	1.84	—1.0	Precipitate.
4.46	3.00	—1.8	Precipitate.	3.66	2.22	—1.5	Precipitate.
4.46	2.08	—1.3	Precipitate.	3.60	0.80	—3.6	Precipitate.
4.46	1.66	—0.5	Precipitate.	3.52	1.54	—0.5	Precipitate.
4.44	3.20	—0.9	Precipitate.	3.42	1.37	—0.3	Precipitate.
4.44	2.80	—1.8	Precipitate.	3.34	2.73	—0.9	Precipitate.
4.44	2.22	—1.4	Precipitate.	3.28	0.90	—1.2	Precipitate.
4.44	2.06	—3.5	Precipitate.	3.12	1.69	—0.7	Precipitate.
4.44	1.54	—1.3	Precipitate.	3.10	1.65	—0.5	Precipitate.
4.44	1.50	—1.0	Precipitate.	3.00	1.94	—1.0	Precipitate.
4.42	2.60	—3.3	Precipitate.	3.00	1.94	—1.0	Precipitate.
4.40	3.86	—2.5	Precipitate.	3.00	1.89	—0.3	Precipitate.
4.40	2.54	—3.2	Precipitate.	3.00	1.77	—1.9	Precipitate.
4.40	2.49	—1.7	Precipitate.	2.90	1.23	—1.7	Precipitate.
4.40	2.36	—1.4	Precipitate.	2.74	1.72	—0.4	Precipitate.
4.40	2.12	—2.3	Precipitate.	2.21	2.20	—1.2	Precipitate.

Vinegar not the Exclusive Product of Pure Apple Cider.

Acid (Per Cent.).	Solids (Per Cent.).	Polarization in Ventzke 200 Millimeter Tube.	Lead Acetate.	Acid (Per Cent.).	Solids (Per Cent.).	Polarization in Ventzke 200 Millimeter Tube.	Lead Acetate.
5.70	0.60	+0.4	No precipitate.	4.60	2.63	—2.0	No precipitate.
5.50	0.76	+0.4	Cloudy.	4.60	1.90	—0.6	Slight precipitate
5.20	1.44	+0.3	No precipitate.	4.59	0.37	0.0	No precipitate.
5.18	1.75	—1.2	Cloudy.	4.58	2.53	—3.1	Cloudy.
5.12	0.38	+0.1	No precipitate.	4.54	2.74	+0.8	Precipitate.
5.04	2.03	+2.1	Precipitate.	4.52	1.80	+1.8	Precipitate.
5.00	2.80	+1.7	Slight precipitate.	4.52	1.69	+3.2	No precipitate.
4.98	2.36	—3.1	Cloudy.	4.52	0.65	-	No precipitate.
4.94	2.13	—1.3	Slight precipitate.	4.50	2.60	+3.1	Precipitate.
4.90	0.80	—0.8	No precipitate.	4.50	2.40	+2.6	Slight precipitate.
4.90	0.31	0.0	No precipitate.	4.50	1.74	+2.8	Slight precipitate.
4.88	1.07	0.0	No precipitate.	4.50	1.60	0.0	No precipitate.
4.86	2.04	+0.4	Precipitate.	4.48	3.80	+12.0	No precipitate.
4.82	2.43	—3.6	Slight precipitate.	4.48	2.90	+1.0	No precipitate.
4.82	0.56	+0.2	No precipitate.	4.48	2.50	—0.9	No precipitate.
4.80	7.00	+7.6	Precipitate,	4.45	0.35	—1.1	No precipitate.
4.80	2.30	—0.5	Cloudy.	4.44	0.51	0.0	No precipitate.
4.80	2.27	+4.8	No precipitate.	4.44	0.50	+0.2	No precipitate.
4.80	1.80	+0.6	Slight precipitate.	4.42	0.32	+0.8	No precipitate.
4.78	0.58	+0.2	No precipitate.	4.40	2.80	+10.5	Precipitate.
4.78	0.45	0.0	No precipitate.	4.40	1.50	+0.2	Slight precipitate.
4.76	2.40	+1.5	Slight precipitate.	4.35	3.40	+5.2	No precipitate.
4.74	2.80	+2.8	Slight precipitate.	4.32	2.09	—1.6	Slight precipitate.
4.72	0.74	—0.9	No precipitate.	4.32	2.09	—1.6	Slight precipitate.
4.72	0.71	+1.0	No precipitate.	4.32	1.60	+0.2	Cloudy.
4.70	1.89	+1.3	Precipitate.*	4.30	3.50	+3.2	No precipitate.
4.70	0.28	0.0	No precipitate.	4.24	2.70	+1.9	No precipitate.
4.68	2.09	—1.1	Cloudy.	4.00	0.73	+0.6	No precipitate.
4.68	2.06	—3.8	Cloudy.	3.80	1.00	-	No precipitate.
4.66	3.51	+7.2	Slight precipitate.	3.70	1.20	—1.1	No precipitate.
4.66	2.13	+3.6	No precipitate.	3.50	0.57	-	No precipitate.
4.66	0.75	0.0	No precipitate.	4.46	1.06	+2.8	Slight precipitate.
4.66	0.71	0.0	No precipitate.	2.76	0.29	+0.4	No precipitate.
4.64	2.57	—2.2	No precipitate.	2.66	1.31	+0.7	Cloudy.
4.64	0.53	+0.4	No precipitate.	2.50	4.00	+0.7	No precipitate.
4.62	2.60	—5.7	Slight precipitate.	1.64	1.19	+1.1	Precipitate.
4.60	2.87	+0.9	Precipitate.*	1.00	4.60	+1.2	Precipitate.
4.60	2.85	+10.0	Precipitate.				

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* By the calcium chloride test, these samples were found to contain no malates.

The following shows in a summarized form the results of the analysis of 84 samples of undoubtedly pure cider vinegar: —

	Acid (Per Cent.).	Solids (Per Cent.).	Polarization.
Maximum,	6.36	4.00	—5.4
Minimum,	4.50	2.01	—0.4
Mean,	4.84	2.43	—2.0

The following analyses were made of 4 cider vinegars of known purity, the first 2 of which were fifteen years old : —

Acid (Per Cent.).	Solids (Per Cent.).	Ash (Per Cent.).	Alkalinity of the Ash.*	Polarization in 200 Millimeter Tube.
4.04	6.85	0.42	26.3	—2.0
9.30	5.09	0.58	45.3	—1.4
5.63	2.04	0.36	31.2	—1.1
4.81	2.45	0.38	28.2	—0.9

* Number of cubic centimeters of tenth normal acid necessary to neutralize the ash of 100 cubic centimeters of vinegar.

Two samples of vinegar, the products of the Albion Cider & Vinegar Company of Rochester, New York, were the subjects of closely contested court cases, in which expert chemists were employed by the defendants to show that they were genuine cider vinegar, the charge being that they were not exclusively the product of pure apple cider. There was no difficulty, however, in proving the spurious nature of this vinegar, in view of the fact that one of them polarized more than 12° to the right in a 200 millimeter tube, that malates were practically absent and that more than fifty per cent. of the solids was made up of commercial glucose.

Test for Malic Acid in Vinegar. — Add a few drops of a 10 per cent. solution of calcium chloride to some of the vinegar in a test tube and make the mixture slightly alkaline with ammonia. Remove by filtration the precipitate which occurs at this point, and to the filtrate add three volumes of alcohol. A copious flocculent precipitate will form if malic acid is present, settling to the bottom of the tube in a few minutes.

MISCELLANEOUS FOODS.

Samples of the following foods and condiments were examined and found to be pure, or of good standard quality : apple jelly, acid phosphate, brandy drops, baking powder, "cocoa-coffee," coffee substitute, caper sauce, "creamette" (a dessert preparation), dried apples, mixed spices, patent barley food, rolls, soda, and "tryphosia" (a dessert preparation).

Miscellaneous samples worthy of comment are the following: —

Cider. — The single sample of bottled cider examined was found to contain salicylic acid.

Jams and Jellies. — Twelve samples of these preparations were examined, only one of which was found to be of good standard quality. Many of the adulterated samples contained formulæ on the labels, but those formulæ were misleading, in that they did not state *all* the ingredients regarded as adulterants. Frequently when artificial colors were present this was not stated in the formula. The same was often true in regard to preservatives. Seven of the samples examined contained benzoic acid as a preservative, while 3 contained salicylic acid.

Method for detecting Benzoic Acid. — The ordinary test for benzoic acid by extraction with ether, separating with ammonium hydrate and treating with ferric chloride after the ammonia has been driven off, as detailed in the analyst's report of 1899, page 640, is frequently unsatisfactory in the case of highly colored jellies and jams, especially when the coloring matter employed is soluble in ether. In this case the characteristic color of the ferric benzoate is apt to be obscured by the coal tar dye.* In such cases the following method of procedure is adopted: extract the acidified sample with ether, add ammonia to the ether extract in excess and evaporate to dryness in a large watch-glass. Fasten with clips or otherwise another watch-glass of the same size above it, thereby forming a double convex shell, a sheet of filter paper being preferably interposed between the two glasses, and heat the lower watch-glass on a small sand bath or over a low flame. If benzoic acid is present, crystals of the same will be sublimed on the upper watch-glass, where they may be recognized under the microscope, or they may be dissolved in dilute ammonia, the solution evaporated to dryness, the residue taken up in water and the final solution tested by ferric chloride in the usual manner.

Grape Juice. — Six brands were examined, 2 of which contained salicylic acid. These were "Fine Fruit Grape Shrub," put out by J. Hungerford, Rochester, N. Y., and "Fenner's Chatauqua Grape Juice," manufactured by Fenner's Chatauqua Fruit and Grape Juice Company, Westfield, N. Y.

Ketchup. — Two brands were examined, both of which were found to contain no added preservative, but to be colored with a coal-tar dye. They were therefore classed as adulterated, because they bore no label stating the presence of color. As an example of the character of the material used in many of the cheaper preparations of tomato ketchup, the following quotations are of interest, taken from the circular of a commission merchant outside the state, the circular being headed in large letters "Tomato Pulp for Sale," and advertising some 12 different grades for use in making ketchup: —

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* The test as ordinarily carried out is also inapplicable to such products as sweet pickles, in which benzoic acid has been used as a preservative, by reason of the precipitate of basic ferric acetate when the ferric chloride is finally applied.

"One hundred barrels old goods, made partly from whole stock and partly waste, boiled down nearly to catsup thickness, *has preservaline in it*; fine goods but some of it is fermented; packed in good oak whiskey and wine barrels. Price, $2 per barrel."

"Two hundred and twenty-five barrels new goods, made from waste, *has benzoate of soda in it*, packed in good whiskey and wine barrels, at $3 per barrel net cash."

"Three hundred barrels old goods, partly whole stock, partly waste, *has salicylic acid in it*; nice goods, but some of it is fermented. Price, $2 per barrel."

"Four hundred barrels new goods, Jersey style, *good red color*. Price, $3 per barrel."

With prices as low as the above quotations indicate, it is difficult to see how a cheaper basis for ketchup than real tomato stock could be supplied, so that pumpkin pulp and other materials alleged to be used for such preparations could not be furnished at a much lower price.

Lime Juice. — Five brands were examined, as follows: —

BRAND.	Acidity.	Preservative or Color.
Hub,	3.02	– –
Montego,	2.29	Salicylic acid.
Geer's,	1.66	Sulphurous acid.
Superior Crescent,	2.37	Salicylic acid.
Ginter's,*	2.75	Sulphurous and salicylic acid, also colored.

Raspberry Shrub. — The single sample examined was found to be colored with a coal-tar dye.

Edible Fats and Oils. — Considerable experimental work has been done during the year on the refractometric readings of the various edible oils and fats, using the Zeiss butyro-refractometer. Results showing readings at various temperatures have for convenience been compiled, as follows: —†

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* Since marked with a correct formula.

† See also Lythgoe Technology Quarterly, September, 1903.

Readings on Butyro-refractometer of Edible Oils and Fats.

TEMPERATURE C.	Cocoanut Oil.	Butter.	Beef Stearine.	Cacao Butter.	Beef Tallow.	Lard Stearine.	Beef Oleo.	Lard.	Lard Oil.
45.0	31.6	41.5	41.9	43.7	44.1	44.9	45.0	48.2	-
44.5	31.9	41.8	42.2	44.0	44.3	45.1	45.3	48.4	-
44.0	32.2	42.0	42.4	44.2	44.6	45.5	45.6	48.7	-
43.5	32.4	42.3	42.6	44.5	44.8	45.7	45.9	49.0	-
43.0	32.7	42.6	42.9	44.8	45.1	46.0	46.1	49.3	-
42.5	32.9	42.9	43.2	45.0	45.4	46.3	46.4	49.6	-
42.0	33.2	43.1	43.5	45.3	45.6	46.5	46.7	49.9	-
41.5	33.5	43.4	43.7	45.6	45.8	46.8	47.0	50.1	-
41.0	33.7	43.7	44.0	45.9	46.1	47.0	47.3	50.4	-
40.5	34.0	43.9	44.2	46.1	46.3	47.3	47.6	50.7	-
40.0	34.3	44.2	44.5	46.4	46.6	47.6	47.8	51.0	51.6
39.5	34.5	44.5	-	46.6	46.8	47.8	48.1	51.3	51.8
39.0	34.8	44.8	-	46.8	47.1	48.1	48.4	51.6	52.1
38.5	35.0	45.0	-	47.1	47.4	48.4	48.7	51.9	52.4
38.0	35.3	45.3	-	47.4	47.6	48.6	48.9	52.1	52.6
37.5	35.5	45.6	-	47.6	47.8	48.9	49.3	52.4	52.8
37.0	35.8	45.9	-	47.9	48.1	49.2	49.5	52.7	53.1
36.5	36.1	46.1	-	48.2	48.3	49.4	49.8	53.0	53.4
36.0	36.3	46.4	-	48.5	48.6	49.7	50.0	53.3	53.7
35.5	36.6	46.7	-	48.7	48.8	50.0	50.3	53.6	54.0
35.0	36.9	47.0	-	49.0	49.1	50.2	50.6	53.9	54.2
34.5	37.1	47.2	-	-	-	-	50.9	54.2	54.5
34.0	37.4	47.5	-	-	-	-	51.2	54.4	54.7
33.5	37.6	47.8	-	-	-	-	51.5	54.7	55.0
33.0	37.9	48.1	-	-	-	-	51.7	55.0	55.3
32.5	38.1	48.3	-	-	-	-	52.0	55.3	55.6
32.0	38.4	48.6	-	-	-	-	52.3	55.6	55.9
31.5	38.6	48.9	-	-	-	-	52.6	55.9	56.1
31.0	38.9	49.2	-	-	-	-	52.8	56.1	56.4
30.5	39.2	49.5	-	-	-	-	53.1	56.4	56.7
30.0	39.5	49.8	-	-	-	-	53.4	56.7	57.0
29.5	39.7	50.0	-	-	-	-	53.7	57.0	57.2
29.0	40.0	50.3	-	-	-	-	53.9	57.3	57.5
28.5	40.3	50.5	-	-	-	-	54.1	57.6	57.8
28.0	40.5	50.8	-	-	-	-	54.4	57.8	58.1
27.5	40.8	51.1	-	-	-	-	54.7	58.1	58.3
27.0	41.0	51.4	-	-	-	-	55.0	58.4	58.6
26.5	41.3	51.6	-	-	-	-	55.2	58.7	58.9
26.0	41.5	51.9	-	-	-	-	55.5	59.0	59.2
25.5	41.8	52.2	-	-	-	-	65.8	59.3	59.5
25.0	42.0	52.5	-	-	-	-	66.1	59.6	59.8

Readings on Butyro-refractometer of Edible Oils and Fats.

TEMPERATURE C.	Olive Oil.	Peanut Oil.	Cotton Seed Oil.	Rape Seed Oil.	Sesame Oil.	Yellow Mustard Oil.	Black Mustard Oil.	Sunflower Oil.	Corn Oil.	Poppy Seed Oil.
35.0	57.0	59.8	61.8	62.1	62.3	63.0	64.2	64.5	65.0	65.5
34.5	57.2	60.0	62.1	62.4	62.5	63.3	64.5	64.8	65.3	65.8
34.0	57.4	60.3	62.3	62.7	62.8	63.6	64.8	65.1	65.6	66.1
33.5	57.7	60.6	62.5	63.0	63.1	63.9	65.1	65.4	65.9	66.4
33.0	58.0	60.9	62.8	63.3	63.4	64.1	65.3	65.7	66.2	66.7
32.5	58.3	61.1	63.0	63.6	63.7	64.4	65.6	66.0	66.5	67.0
32.0	58.5	61.4	63.2	63.8	64.0	64.7	75.9	66.3	66.8	67.3
31.5	59.0	61.7	63.6	64.1	64.3	65.0	66.2	66.6	67.1	67.6
31.0	59.2	62.0	64.0	64.4	64.6	65.3	66.5	66.9	67.4	67.9
30.5	59.5	62.2	64.2	64.7	64.9	65.6	66.8	67.2	67.7	68.2
30.0	59.9	62.5	64.5	65.0	65.1	65.8	67.0	67.5	68.0	68.5
29.5	60.1	62.8	64.9	65.3	65.4	66.1	67.3	67.7	68.3	68.7
29.0	60.3	63.1	65.1	65.6	65.7	66.4	67.6	68.0	68.5	69.0
28.5	60.6	63.3	65.3	65.9	66.0	66.7	67.9	68.3	68.8	69.3
28.0	60.9	63.6	65.7	66.1	66.2	66.9	68.1	68.6	69.1	69.6
27.5	61.1	63.9	66.0	66.4	66.5	67.2	68.4	68.9	69.4	69.9
27.0	61.5	64.2	66.5	66.7	66.8	67.5	68.7	69.2	69.7	70.2
26.5	62.0	64.4	67.0	67.0	67.1	67.8	69.0	69.5	70.0	70.5
26.0	62.2	64.7	67.3	66.3	67.4	68.0	69.2	69.8	70.3	70.8
25.5	62.4	65.0	67.5	67.6	67.7	68.3	69.5	70.1	70.6	71.1
25.0	63.0	65.3	67.9	67.8	67.9	68.6	69.8	70.4	70.9	71.4
24.5	63.3	65.5	68.2	68.1	68.2	68.9	70.1	70.7	71.2	71.7
24.0	63.6	65.8	68.5	68.4	68.5	69.2	70.4	71.0	71.5	72.0
23.5	63.9	66.1	68.8	68.7	68.8	69.5	70.7	71.3	71.8	72.3
23.0	64.2	66.4	69.1	69.0	69.1	69.7	70.9	71.6	72.1	72.6
22.5	64.5	66.6	69.4	69.3	69.4	70.0	71.2	71.9	72.4	72.9
22.0	64.8	66.9	69.7	69.7	69.7	70.3	71.5	72.2	72.7	73.2
21.5	65.1	67.1	70.0	70.0	70.0	70.6	71.8	72.6	73.0	73.5
21.0	65.4	67.4	70.3	70.3	70.3	70.9	72.1	72.8	73.3	73.8
20.5	65.7	67.7	70.6	70.6	70.6	71.2	72.4	73.1	73.6	74.1
20.0	66.0	68.0	70.9	70.8	70.8	71.4	72.6	73.4	73.9	74.4
19.5	66.3	68.2	71.2	71.1	71.1	71.7	72.9	73.6	74.1	74.6
19.0	66.6	68.5	71.5	71.4	71.4	72.0	73.2	73.9	74.4	74.9
18.5	66.9	68.8	71.8	71.7	71.7	72.3	73.5	74.2	74.7	75.2
18.0	67.2	69.1	72.1	72.0	72.0	72.6	73.8	74.5	75.0	75.5
17.5	67.5	69.3	72.4	72.3	72.3	72.9	74.1	74.8	75.3	75.8
17.0	67.8	69.6	72.7	72.6	72.5	73.1	74.3	75.1	75.6	76.1
16.5	68.1	69.9	73.0	72.9	72.8	73.4	74.6	75.4	75.9	76.4
16.0	68.4	70.2	73.3	73.2	73.1	73.7	74.9	75.7	76.2	76.7
15.5	68.7	70.5	73.6	73.5	73.4	74.0	75.2	76.0	76.5	77.0
15.0	68.9	70.8	73.8	73.8	73.7	74.3	75.5	76.3	76.8	77.3

Summary of Statistics of Food, exclusive of Milk.

	Genuine.	Adulterated.	Total.	Per Cent. of Adulteration.
Allspice,	192	7	199	3.5
Butter,	124	41	165	24.8
Canned goods,	4	4	8	50.0
Cassia,	210	5	215	2.3
Cayenne,	60	6	66	9.0
Cheese,	27	–	27	0.0
Chocolate and cocoa,	27	18	45	40.0
Cloves,	165	31	196	15.8
Coffee,	123	2	125	1.6
Condensed milk,	60	8	68	11.7
Confectionery,	30	1	31	3.2
Cream of tartar,	324	2	326	0.6
Flavoring extracts:				
Lemon,	3	11	14	78.5
Vanilla,	3	15	18	83.3
Ginger,	232	17	249	6.8
Honey,	28	15	43	34.8
Lard,	18	4	22	18.2
Mace,	12	12	24	50.0
Maple sugar,	6	–	6	0.0
Maple syrup,	23	5	28	17.8
Miscellaneous,	46	34	80	42.5
Molasses,	133	13	146	8.9
Mustard,	195	90	285	31.5
Nutmeg,	7	–	7	0.0
Pepper,	350	33	383	8.6
Tea,	44	–	44	0.0
Vinegar,	92	178	270	65.9
Total,	2,538	552	3,090	17.8

DRUGS.

The pharmacopœial drugs examined, with the results of the analyses as regards their relations to the standard, are summarized on page 493. Special comment is made on the following articles: —

Acidum Tannicum. — Ten samples of the 14 examined were found impure by reason of the presence of resinous and gummy matters, showing insufficient washing.

Aqua Destillata. — All 7 of the distilled water samples examined were found to have an appreciable residue on evaporation, in one case amounting to 26 parts per 100,000. There is reason to believe that ordinary tap-water is too often substituted for the distilled variety.

Capsicum. — Great improvement is shown in the general character of this and other spices dispensed in the drug stores over that of past years. Ten samples only, out of the 79 examined, were found to be adulterated. The worst sample consisted almost entirely of buckwheat, turmeric and a coal-tar dye. Other adulterants found were wheat and corn.

Cera Alba and Cera Flava. — More than half of the waxes examined were found to be adulterated with paraffin.

Extractum Glycyrrhizæ. — One sample was found to be adulterated, containing added corn starch.

Glycerinum. — Nineteen samples out of the 143 examined were found to be slightly arsenical, showing a marked improvement over past years.

Liquor Calcis. — Six of the 13 samples examined were found to be below the standard fixed by the Pharmacopœia, a standard which is somewhat lower than our experience with properly prepared lime water would seem to warrant. The worst sample contained 57 per cent. of the strength required.

Oleum Caryophylli. — The two adulterated samples of this oil were found to contain alcohol, in one case to the extent of 17 per cent. Methods for the detection and determination of alcohol in essential oils are given in the analyst's report for 1901, page 476.

Oleum Limonis. — Twenty-four samples were examined, 17 of which were found to be adulterated by reason of the presence of alcohol or turpentine.

Oleum Olivæ. — Thirty-two samples, amounting to about one-third of those examined, were adulterated. Most of the adulterated samples consisted wholly or in part of cotton-seed oil. One was found to be cod-liver oil, but undoubtedly was sold by mistake; another sample contained from 11 to 12 per cent. of cocoa-nut oil, the latter being rendered apparent by the abnormally high Reichert-Meissl number, and low iodine number and refractive index; a third sample contained sesame oil, as shown by the Badouin test.*

Pulvis Glycyrrhizæ Compositus. — Only 1 sample of the 22 examined was found to be impure, by reason of added wheat starch.

Quininæ Sulphas. — Twenty-five samples were examined, 1 of which was found with more of the other cinchona alkaloids than the Pharmacopœia allows.

Sodii Boras. — Twelve samples were examined, 4 of which consisted largely of sodium bicarbonate.

Sodii Phosphas. — Seventeen samples out of the 141 examined were found to be arsenical beyond the limit fixed by Pharmacopœia. One sample, which was prosecuted in court, contained 80 parts per 100,000, or nearly one-tenth of 1 per cent of arsenic.

Spiritus Frumenti. — Only 1 sample out of the 8 examined was found to conform to the pharmacopœial requirements. All the others were low in alcohol, or high in residue, or had insoluble residues.

Sulphur Lotum and Sulphur Præcipitatum. — More than half the washed sulphurs were found not to have been properly washed, and all of the precipitated sulphurs contained lime.

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* Bulletin 65, Bureau of Chemistry, United States Department of Agriculture, page 34.

Spiritus Ætheris Nitrosi. — Thirty-six samples out of the 40 examined were found to contain insufficient nitrogen dioxide. One sample contained but 2 per cent. of the required amount.

Tinctura Iodi. — Of the 201 samples analyzed, 183 did not conform to the standard. The results of the analysis of these samples expressed in percentage of the required United States pharmacopœial strength are as follows: —

4 samples were above the United States pharmacopœial strength.
17 samples were between 90 and 95 per cent. of the United States pharmacopœial strength.
47 samples were between 80 and 90 per cent. of the United States pharmacopœial strength.
57 samples were between 70 and 80 per cent. of the United States pharmacopœial strength.
29 samples were between 60 and 70 per cent. of the United States pharmacopœial strength.
13 samples were between 50 and 60 per cent. of the United States pharmacopœial strength.
9 samples were between 40 and 50 per cent. of the United States pharmacopœial strength.
5 samples were between 30 and 40 per cent. of the United States pharmacopœial strength.
2 samples were under 20 per cent. of the United States pharmacopœial strength.

Tinctura Opii. — Ten samples of laudanum were examined, 8 of which were found below the standard. The weakest sample contained .08 per cent. of crystallized morphine.

MISCELLANEOUS DRUGS.

Intemperance Cures. — Dr. Grant's "Goldcura," for the liquor and drug habits, manufactured by the Canadian Chemical Company, Rutland, Vt., and sold for $5 per package, consisted of two bottles of liquid and one small bottle containing pills. The two liquids were found to contain 41.11 per cent. and 28.22 per cent. of alcohol by volume respectively, while the pills contained nux vomica and were coated with a very thin layer of gold foil, which, by the way, was the only gold found in the preparation.

The White Ribbon Remedy, put up by Dr. W. R. Brown of Boston, purporting to contain gold and alkaloids, consisted of twelve powders in a box sold for $1. These powders were found to contain ammonium chloride and milk sugar. Neither gold nor alkaloids were found to be present.

Champagne Tablets. — This preparation, prepared by the Champagne Tablet Company of Boston, claiming to be a stimulating and exhilarating substitute for brandy, champagne, whiskey, etc., was put out in the form of lozenges containing .05 gram of caffeine per tablet.

Peanut Oil. — A sample of this preparation purchased at a drug store was found to consist largely of cotton-seed oil.

Catarrh Remedy. — One of these preparations was found to contain a considerable amount of cocaine hydrochlorate.

Quinine Pills. — Several brands of these have been examined during the year, nearly all of which were found to contain approximately the required amount of quinine sulphate. One brand of pills, manufactured by Arthur J. Conner of Boston, purporting to contain 2 grains each of quinine sulphate, was found to contain 1.4 grains per pill of total alkaloids. The pills also contained a notable quantity of powdered talc or soapstone (magnesium silicate).

Cigarettes. — The "Star Brand of Medicated Cinnamon Cigarettes," purporting to contain no tobacco, were found to contain a large proportion of the latter in mixture with various aromatic herbs and cassia.

Summary of Drug Statistics.

	Genuine.	Adulterated.	Total.	Per Cent. of Adulteration.
Acidum tannicum, ...	4	10	14	71.4
Æther, ...	5	1	6	16.6
Alcohol, ...	6	6	12	50.0
Aqua ammoniæ fortior, . . .	1	3	4	75.0
Aqua destillata, ...	–	7	7	100.0
Capsicum, ...	69	10	79	12.6
Cera alba, ...	3	6	9	66.6
Cera flava, ...	32	40	72	55.5
Chloroformum, ...	1	2	3	66.6
Extractum glycyrrhizæ, . .	1	1	2	50.0
Ferri et quininæ citras, . . .	6	–	6	.0
Glycerinum, ...	124	19	143	13.3
Liquor calcis, ...	7	6	13	46.1
Maranta, ...	31	–	31	.0
Miscellaneous, ...	29	24	53	45.3
Oleum caryophylli, ...	2	2	4	50.0
Oleum limonis, ...	7	17	24	70.8
Oleum olivæ, ...	71	32	103	31.0
Opii pulvis, ...	2	1	3	33.3
Potassii bitartras, ...	3	–	3	.0
Pulvis glycyrrhizæ compositus, .	21	1	22	4.5
Quininæ sulphas, ...	24	1	25	4.0
Sodii boras, ...	8	4	12	33.3
Sodii phosphas, ...	124	17	141	12.0
Sodii phosphas effervescens, . .	5	–	5	.0
Spiritus ætheris nitrosi, . . .	4	36	40	90.0
Spiritus frumenti, ...	1	7	8	87.5
Sulphur lotum, ...	11	29	40	72.5
Sulphur præcipitatum, . . .	–	11	11	100.0
Syrupus, ...	6	3	9	33.3
Tinctura iodi, ...	18	183	201	91.0
Tinctura opii, ...	2	8	10	80.0
Zingiber, ...	8	1	9	11.1
Total, ...	636	488	1,124	43.4

Summary of Food and Drug Statistics for Year ending Sept. 30, 1902.

	Genuine.	Adulterated.	Total.	Per Cent. Adulterated.
Milk,	3,956	1,914	5,870	32.6
Food exclusive of milk,	2,538	552	3,090	17.8
Drugs,	636	488	1,124	43.4
Total,	7,130	2,954	10,084	29.2

PROPRIETARY MEDICINES.

In the twenty-eighth annual report of the Board, for 1896, a condensed compilation was made of the results of certain examinations of proprietary medicines made in prior years by the analysts of the Board and scattered through various reports.

Frequent requests are continually made for copies of this report, and in view of the fact that it is now out of print and further copies are unavailable, it has been thought best to reprint most of the data contained therein relating to lead in cosmetics, alcohol in tonics and bitters, etc., calling attention to the fact that most of the reprinted analyses were made prior to 1897, and represent the condition of the various preparations at the time they were collected. In most cases the preparations were examined for the presence of a single ingredient only, to which it was thought best to call especial attention on account of its questionable effect upon health.

Cosmetics.

The following were found to contain acetate of lead (sugar of lead) or some active lead compound: —

	Per Cent. of Lead contained.
Ayer's Hair Vigor contained the equivalent of about	0.30
"Renown" Hair Restorer contained the equivalent of about	1.86
Mrs. Allen's Hair Restorer contained the equivalent of about	2.30
American Hair Restorative contained the equivalent of about	0.61
Barrett's Vegetable Hair Restorative contained the equivalent of about	0.22
Chevalier's Life for the Hair contained	Much
Hall's Vegetable Sicilian Hair Renewer contained the equivalent of about	1.75
Wood's Hair Restorative contained the equivalent of about	1.59
Ring's Vegetable Ambrosia contained the equivalent of about	1.51
Parker's Hair Balsam contained the equivalent of about	2.32
Wolf's Vegetable Hair Restorer contained the equivalent of about	0.95
Champlin's Liquid Pearl,	Much

Instances of lead poisoning have been known to occur from the free external use of such preparations as the foregoing.

The following contained corrosive sublimate, or some other poisonous salt of mercury, in the proportion of 1 to 15 grains per ounce: —

Harriet Hubbard Ayer's Recamier Cream, Balm and Lotion.
Madam Ruppert's World Renowned Face Bleach.
Madam Yale's Excelsior Complexion Bleach.
Hill's Freckle Lotion.
Soule's Freckle and Moth Eradicator.
Perry's Freckle Lotion.
Oriental Cream.
Mrs. McCorrison's Famous Diamond Face Lotion (14.7 grains to the ounce).
Royal Cream.

In one instance a six-ounce bottle contained 47 grains of corrosive sublimate; another contained 14 grains of the bichloride per ounce. It is not surprising that instances of serious harm were reported from the use of such articles.

Tonics and Bitters.

The following were examined for the purpose of ascertaining the percentage of alcohol in each. Some of them have been recommended as temperance drinks: —

	Per Cent. of Alcohol (by Volume).
"Best" Tonic,	7.6
Carter's Physical Extract,	22.0
Hooker's Wigwam Tonic,	20.7
Hop Tonic,	7.0
Hoofland's German Tonic,	29.3
Howe's Arabian Tonic, "not a rum drink,"	13.2
Jackson's Golden Seal Tonic,	19.6
Liebig Company's Coca Beef Tonic,	23.2
Mensman's Peptonized Beef Tonic,	16.5
Parker's Tonic, "purely vegetable," recommended for inebriates,	41.6
Schenck's Sea Weed Tonic, "entirely harmless,"	19.5
Atwood's Quinine Tonic Bitters,	29.2
L. T. Atwood's Jaundice Bitters,	22.3
Moses Atwood's Jaundice Bitters,	17.1
Baxter's Mandrake Bitters,	16.5
Boker's Stomach Bitters,	42.6
Brown's Iron Bitters,	19.7
Burdock Blood Bitters,	25.2
Carter's Scotch Bitters,	17.6
Colton's Bitters,	27.1
Copp's White Mountain Bitters, "not an alcoholic beverage,"	6.0
Drake's Plantation Bitters,	33.2
Flint's Quaker Bitters,	21.4
Goodhue's Bitters,	16.1
Greene's Nervura,	17.2
Hartshorn's Bitters,	22.2

	Per Cent. of Alcohol (by Volume).
Hoofland's German Bitters, "entirely vegetable and free from alcoholic stimulant,"	25.6
Hop Bitters,	12.0
Hostetter's Stomach Bitters,	44.3
Kaufman's Sulphur Bitters, "contains no alcohol" (as a matter of fact, it contains 20.5 per cent. of alcohol and no sulphur),	20.5
Kingsley's Iron Tonic,	14.9
Langley's Bitters,	18.1
Liverpool's Mexican Tonic Bitters,	22.4
Paine's Celery Compound,	21.0
Pierce's Indian Restorative Bitters,	6.1
Puritana,	22.0
Z. Porter's Stomach Bitters,	27.9
Pulmonine,	16.0
Rush's Bitters,	35.0
Richardson's Concentrated Sherry Wine Bitters,	47.5
Secor's Cinchona Bitters,	13.1
Shonyo's German Bitters,	21.5
Job Sweet's Strengthening Bitters,	29.0
Thurston's Old Continental Bitters,	11.4
Warner's Vinegar Bitters, "contains no spirit,"	6.1
Warner's Safe Tonic Bitters,	35.7
Warren's Bilious Bitters,	21.5
Wheeler's Tonic Sherry Wine Bitters, 19,	18.8
Wheat Bitters,	13.6
Faith Whitcomb's Nerve Bitters,	20.3
Dr. Williams's Vegetable Jaundice Bitters,	18.5
Whiskol, "a non-intoxicating stimulant, whiskey without its sting,"	28.2
Colden's Liquid Beef Tonic, "recommended for treatment of alcohol habit,"	26.5
Ayer's Sarsaparilla,	26.2
Thayer's Compound Extract of Sarsaparilla,	21.5
Hood's Sarsaparilla,	18.8
Allen's Sarsaparilla,	13.5
Dana's Sarsaparilla,	13.5
Brown's Sarsaparilla,	13.5
Corbett's Shaker Sarsaparilla,	8.8
Radway's Resolvent,	7.9

The dose recommended upon the labels of the foregoing preparations varied from a teaspoonful to a wineglassful, and the frequency also varied from one to four times a day, "increased as needed."

"*Blood Purifiers.*"

An examination of the "sarsaparilla" remedies, or "blood purifiers," was made in 1892, and in nearly every instance the remedy was found to contain iodide of potassium in variable amounts.

The following list presents the percentage of iodide of potassium found in those samples which have been submitted to the analyst for examination : —

Sarsaparilla Remedies.

NAME.	Per Cent. of Iodide of Potassium.	NAME.	Per Cent. of Iodide of Potassium.
Wilson's,	0.32	Woodward's,	1.33
Howe's,	0.33	Dudley's,	1.50
White's,	0.38	Cherry & Wingate's,	1.55
No name,	0.41	Jaynes's,	1.59
Charles's,	0.41	Nim's,	1.67
Mahern's,	0.41	Raynsford's,	0.58
Ayer's,	0.45	Adams's,	0.75
Bartlett's,	0.50	Broad & Co.'s,	0.75
No name,	0.50	Hood's,	0.75
No name,	0.50	Hutchinson's,	0.75
Packard's,	0.58	Dr. White's,	0.75
Coleman & Co's,	0.83	Cherry & Wingate's,	1.67
Bass's,	0.84	Mattison's,	2.00
Brown's,	1.00	Myrick's,	2.12
Leavitt's,	1.00	Leavitt's,	2.17
Moriarty's,	1.11	Church's,	2.25
Dana's,	1.17		

Supplementary to the above lists as quoted from the 1896 report are given the following results, obtained more recently : —

*Starch in Diabetic Flour or Gluten.**

Per Cent. Starch.	Price per Pound (Cents).	Label on Package.	Manufacturer.
10.00	30	Cestus Diabetic Flour,	American Health Food Company.
16.66	20	Cestus Diabetic Flour,	American Health Food Company.
18.00	–	Cestus Diabetic Flour,	American Health Food Company.
56.20	50	Pure Vegetable Gluten,	T. Metcalf Company.
64.28	25	Whole Wheat Gluten,	Health Food Company, New York.
63.38	15	Bulk,	American Health Food Company.
64.29	11	Bulk,	Johnson Educator Food Company.
64.46	30	Unsurpassed Gluten Flour,	Johnson Educator Food Company.
64.29	–	Bulk,	– –
68.74	–	Bulk,	– –
59.04	–	Gum Gluten,† "Protein in its purest form."	The Pure Gluten Food Company, New York.

* From report of 1899, State Board of Health, page 644. † Analyzed in 1902.

Also the following medicines for alcohol : —

	Per Cent. of Alcohol (by Volume).
Hoff's Extract of Malt and Iron,	5.24
Peruna,	28.59
Vinol, Wine of Cod Liver Oil,	18.88
Lydia Pinkham's Vegetable Compound,	20.61
Dr. Kilmer's Swamp Root,	7.32
Dr. Peter's Kuriko,	14.00

Arsenic in Paper, Fabrics, etc.

During the year ending Dec. 31, 1902, the work done under chapter 213, section 6, of the Revised Laws is summarized as follows: —

Arsenic Samples, Year Ending Dec. 31, 1902.

	Above Legal Limit.	Below Legal Limit.	Total.
Enamel cloth,	1	–	1
Wall papers,	4	13	17
Cloth,	4	7	11
Miscellaneous,	2	1	3
Totals,	11	21	32

Of the wall papers found to contain arsenic above the legal limit of one-tenth of a grain per square yard, 3 samples were of a peculiar soft grain and texture intended to resemble cloth, and were found to contain respectively .3 grain, .5 grain and 1.4 grains per square yard, the latter sample being of a pale green color. One sample of white enamelled cloth contained exactly .1 grain per square yard. A sample of green window shade material was also found to contain arsenic slightly above the limit. The worst cases of arsenical goods were found to be four samples of striped awning cloth, on account of which prosecutions were brought in court. These samples contained from 9.8 to 12.6 grains of metallic arsenic per square yard. Their high arsenical content was claimed to be due to insufficient washing or to neglect of washing before the goods left the factory.

Inspection of Liquors.

By chapter 110 of the Acts of 1902, the duties before exercised by a specially appointed inspector and assayer of liquors were transferred to the State Board of Health. All samples regularly submitted by the proper officers of the towns and cities throughout the State have been analyzed by the writer. For the fraction of the year ending Dec. 31, 1902, 108 samples have been analyzed, prosecutions in court being the result in many cases. The following circular regarding liquor inspection was prepared by the Board and sent out for the information of those having to do with the seizure of liquors: —

Commonwealth of Massachusetts.

STATE BOARD OF HEALTH.

Circular relating to Inspection of Liquors.

Boston, Mass., March 1, 1902.

The attention of selectmen and others is called to chapter 110, Acts of 1902, in accordance with which the powers hitherto exercised by the Inspector and Assayer of Liquors have been transferred to the State Board of Health. Your attention is called to the following points: —

All packages sent by express must be sealed and prepaid. They should be addressed to the analyst of the State Board of Health, Room 501, State House, Boston. Each sample must be accompanied by a certificate, as required by chapter 100 of the Revised Laws, and must bear a mark or label corresponding with the certificate.* It is much better to send an officer with the sample than to send by express. Beer should be in pint or other round beer bottles. Flat flasks frequently burst in warm weather.

Beer kept in a warm place often ferments, thus increasing the amount of alcohol. The question is frequently asked in court, "How long after seizure has this been kept?" To meet this point, due diligence should be used in forwarding the sample. All beer, if possible, should be forwarded the day it is seized.

Liquors sent under sections 46 and 67 of chapter 100 of the Revised Laws must be sealed and accompanied by an order from the proper authorities, as named in section 67.

All analyses of liquors are made without expense to the town or city requesting such examinations.

Directions for taking Samples for Analysis.

The officer making a seizure, or taking samples of beer, should note at the time of such seizure the general appearance of the liquor, — as to whether it is clear or cloudy, whether it is still or has a strong head.

If the liquor is in bottles, take at least one pint bottle; if in barrels, draw a pint bottle from each. Request the owner to seal each sample taken. If the bottles have cork stoppers, cut the stoppers off level with the top of the bottle and cover with wax; if with patent stoppers, a little wax placed upon the wire at the point where it lays against the neck of the bottle is sufficient. If the owner refuses to seal it, then the officer should seal it in his presence, calling his attention to the fact. Before leaving the premises, place upon the bottle a label or tag, with the date, the name of the owner and the name of the officer upon it, and also the name of the town or city. Then place in a box, with the certificate required by law, and forward without delay to the analyst.

FORM OF LABEL.

Town ______________________________

Date of seizure ______________________ 19

Owner ______________________________

Kind of liquor ________________________

Brewer _____________________________

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* These certificates can be obtained on application to the Secretary of the Commonwealth.

The form of certificate accompanying each sample, returnable to the officer after examination by the analyst, is as follows. This certificate is intended to be accepted as evidence in cases of prosecutions.

____________________ss.____19 .

To the State Board of Health:

I send herewith a sample of____
taken from liquors seized by me____________________________19 .

Ascertain the percentage of alcohol it contains, by volume, at sixty degrees Fahrenheit, and return to me a certificate herewith upon the annexed form.

Seized from__________________________

____

____

Commonwealth of Massachusetts.

No.____

OFFICE OF THE

STATE BOARD OF HEALTH.

BOSTON,____________________19 .

This is to certify that the______________________________received by me with the above statement contains $\frac{\qquad\qquad\qquad}{100}$ per cent. of alcohol, by volume, at sixty degrees Fahrenheit.

Received____________________________19 .
Analysis made_______________________19 .

[SEAL.]

____
Analyst State Board of Health.

Analyses of liquors are kept on record in the food and drug laboratory of the Board on library cards, as follows: —

No.______
County______________________________
City or Town________________________
Officer_____________________________
Defendant___________________________
Address_____________________________
Kind of Liquor______________________
Seized______________________________
Received____________________________
How Delivered_______________________
Sealed______________________________

Condition___________________________
Kind of Bottle______________________
Registered__________________________
Analyzed____________________________
Wt. Flask and Alc.__________________
Wt. Flask___________________________
Wt. Alc.____________________________
Sp. Gr. Alc. (60°)__________________
Per Cent. Alcohol___________________
Reported____________________________

Respectfully submitted,

ALBERT E. LEACH,
Analyst.

REPORT

UPON THE

PRODUCTION, DISTRIBUTION AND USE OF DIPHTHERIA ANTITOXIN,

AND UPON BACTERIOLOGICAL DIAGNOSIS,

FOR THE

YEAR ENDED MARCH 31, 1903.

REPORT

UPON THE

PRODUCTION, DISTRIBUTION AND USE OF DIPHTHERIA ANTITOXIN

FOR THE

YEAR ENDED MARCH 31, 1903.

During the eight years ended March 31, 1903, the State Board of Health has carried on the work of producing and distributing antitoxin for the treatment of diphtheria, with the consequent diminution of the fatality of this disease. The work was conducted under the provisions of the organic act creating the Board, whereby it was empowered to "take cognizance of the interests of health and life among the citizens of the Commonwealth."

By an act of 1903, however, definite authority is now given to the Board to "produce and distribute antitoxin and vaccine lymph" for the "use of the people of the Commonwealth" (chapter 480, Acts of 1903).

The following report relates to the work of the Board in this direction during the year ended March 31, 1903, that period having been selected since the work of distribution practically began in April, 1895, although the preparatory work was begun in the fall of 1894.

In the last annual report a summary was presented of the work of the last seven years, with an approximate estimate of the saving of life effected by the general introduction of the use of antitoxin throughout the State. The returns of 1,979 additional cases, reported during the past year, only confirm and add cumulative testimony to the foregoing report. Of these there were 203 deaths, or 10.6 per cent. Of the whole number of cases, however, only 1,401 were determined by examination to be positive cases of diphtheria, and of these 1,401 there were 138 deaths, or 9.8 per cent.

In the table which was published in the report of last year, and is herewith reproduced with the additional figures for 1902, it was shown that while the diphtheria death-rate in the first half of the period had risen to more than 10 per 10,000 of the population nine times in twenty-one years, in the last half of the period it has risen only once above 10 per 10,000, and then only to 10.2. The death-rate from diphtheria had antitoxin not been used in the past eight years, according to a careful calculation published in the last annual report, would have risen to 10.6, 12.4, 11.0, 14.7 and 10.9 in the years 1895, 1896, 1897, 1900 and 1901.

The mean annual death-rate from diphtheria during the past ten years, 1893–1902, during the greater portion of which antitoxin was in use throughout the State, was only 5.03 per 10,000 living, and there are not ten other successive years in the whole period of forty-two years, 1861–1902, in which the death-rate from this disease was so low.

The reported cases of diphtheria in the State in the past five years (not deaths) were as follows: —

1898,	3,980	1901,	9,793
1899,	7,134	1902,	7,036
1900,	12,641		

The total number of deaths from this cause in 1902 was 873, which is the least number in any year except one since 1874.

Death-rate from Diphtheria in Massachusetts, Forty-two Years (1861–1902).

YEARS.	Death-rate from Diphtheria per 10,000 Population.	YEARS.	Death-rate from Diphtheria per 10,000 Population.	YEARS.	Death-rate from Diphtheria per 10,000 Population.	YEARS.	Death-rate from Diphtheria per 10,000 Population.	Estimated Death-rate without use of Antitoxin.
1861,	8.9	1872,	4.9	1883,	8.6	1893,	5.8	–
1862,	9.2	1873,	4.7	1884,	8.6	1894,	7.4	–
1863,	18.2	1874,	5.7	1885,	7.8	1895,	7.1	10.6
1864,	15.9	1875,	11.4	1886,	7.8	1896,	6.6	12.4
1865,	9.3	1876,	19.6	1887,	7.9	1897,	5.5	11.0
1866,	6.4	1877,	18.7	1888,	8.7	1898,	2.6	5.6
1867,	4.5	1878,	14.6	1889,	10.2	1899,	3.7	9.0
1868,	5.7	1879,	13.1	1890,	7.3	1900,	5.3	14.7
1869,	5.4	1880,	13.4	1891,	5.3	1901,	4.1	10.9
1870,	4.6	1881,	13.1	1892,	6.2	1902,	3.0	7.4
1871,	5.0	1882,	9.6	– –	–	– –	–	–

The following summary relates to the operations of the Board relative to the production, distribution and use of diphtheria antitoxin for the twelve months ended March 31, 1903. The use of antitoxin is approximately an index of the prevalence of diphtheria.

As a condition of the use of antitoxin by boards of health, physicians, hospitals and others it was required that a return should be made in each case where antitoxin was used, upon blank forms furnished by the Board, upon which the details of each case were to be recorded.

It should be understood that the Board is not merely a producer and distributer of antitoxin, but, under the provisions of the statutes, the

Board is authorized to "make sanitary investigations and inquiries in respect to the causes of disease, and especially of epidemics, and the sources of mortality." So far, therefore, as the relation of antitoxin to the saving of life from diphtheria is concerned, the Board cannot carry out the provisions of this law unless it is aided by the hearty co-operation of the physicians who use the product which is prepared by the Board, and are, therefore, the best judges as to its efficiency. By far the larger number of returns received by the Board is furnished by the different hospitals now existing in the larger cities, established for the reception of persons suffering with infectious diseases. If practising physicians were as careful as most of the hospital authorities to render an account of the antitoxin which is furnished to them, this report would be much more complete than it is now practicable to make it.

The supervision of antitoxin production has been carried on, as in former years, under the charge of Dr. Theobald Smith, at the Bussey Institute, near the Forest Hills station of the New York, New Haven & Hartford Railroad in Roxbury. The distribution has been conducted at the State House, from the office of the Board.

The strength of the serum employed has varied from 300 to 450 units per cubic centimeter, and the serum has usually been issued in a 5 cubic centimeter vial, containing 1,500 units. For convenience, a vial containing 20 cubic centimeters has also been employed for use where several patients are to be treated at once, or where unusually large doses are used. The serum has been distributed throughout the whole State, wherever it has been called for, to local boards of health, to contagious disease hospitals and to physicians in private practice, the latter being usually supplied through the local boards of health. In many instances the local board of health has placed it in charge of a druggist, where it could be obtained at any time during the day or night.

The total number of packages issued by the Board during the eight years ending with March 31, 1903, was as follows: —

In 1895–1896 (year ending March 31),	1,724 bottles.
In 1896–1897 (year ending March 31),	3,219 bottles.
In 1897–1898 (year ending March 31),	4,668 bottles.
In 1898–1899 (year ending March 31),	12,491 bottles.
In 1899–1900 (year ending March 31),	31,997 bottles.*
In 1900–1901 (year ending March 31),	53,389 bottles.*
In 1901–1902 (year ending March 31),	40,211 bottles,*
In 1902–1903 (year ending March 31),	33,475 bottles.*
Total,	181,174 bottles.

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* These numbers have reference to the actual number of bottles issued in packages of about 1,500 units each. In order to make this comparable with the figures of the first three years (1895-98), a package of 1,000 units should be employed as a standard, so that the 159,072 bottles distributed during the last four years would be equivalent to about 238,600 of the strength at first employed.

An account was kept during the year of the amount of antitoxin employed in each case, with few exceptions, the result of which is shown in the following table: —

AMOUNT OF ANTITOXIN USED.	Number of Cases.	Deaths.	AMOUNT OF ANTITOXIN USED.	Number of Cases.	Deaths.
Less than 1,000 units, . .	15	4	4,000 to 5,000 units, . .	483	27
1,000 to 1,500 units, . .	17	2	5,000 to 10,000 units, . .	362	49
1,500 to 2,000 units, . .	168	11	10,000 to 15,000 units, . .	164	14
2,000 to 3,000 units, . .	76	4	15,000 to 20,000 units, . .	151	32
3,000 to 4,000 units, . .	267	26	20,000 and more units, .	169	33

There were 1,026 reported cases in which the amount of antitoxin administered did not exceed 5,000 units in each case, and there were 846 reported cases in which the dose exceeded 5,000 units. Of these latter there were 484 in which the dose exceeded 10,000 units, and 169 in which it exceeded 20,000.

The whole number of cities and towns to which antitoxin was distributed during the year was 155, or 3 less than those which were published in the report of 1901. Among these are included at least 30 public and private hospitals and other establishments to which distribution was made, the quantity used in these institutions being about one-half of the whole product distributed during the year. The actual number of cities and towns in each year was probably somewhat larger than these figures, since a few of the more distant cities acted as distributing centres for small towns in their neighborhood, and in some instances no returns were made from these towns. This serum was distributed to local boards of health and to physicians in the following cities and towns: —

Number of Bottles of Diphtheria Antitoxin distributed from April 1, 1902, to March 31, 1903.

CITY OR TOWN.	Number of Bottles.	CITY OR TOWN.	Number of Bottles.
Boston:		Boston:	
City Hospital, ...	9,067	Parental School, ...	9
Children's Hospital, ...	1,200	Gwynne Home, ...	3
St. Mary's Infant Asylum, . . .	250	General supply, ...	3,955
Massachusetts Charitable Eye and Ear Infirmary.	176	Lowell, ...	1,923
West End Nursery, ...	66	Gloucester, ...	1,558
Massachusetts Homœopathic Hospital,	58	Cambridge, ...	1,175
Massachusetts General Hospital, .	26	Hospital, ...	200
Schoolship "Enterprise," . . .	12	Somerville, ...	1,104

Number of Bottles of Diphtheria Antitoxin distributed from April 1, 1902, to March 31, 1903 — Continued.

City or Town.	Number of Bottles.	City or Town.	Number of Bottles.
New Bedford,	1,000	Taunton,	84
Worcester,	775	Wakefield,	78
Lynn,	656	Chelmsford,	–
Marlborough,	645	Middlesex Truant School,	75
Lawrence,	500	Haverhill,	72
Brookline,	493	Melrose,	72
Fall River,	444	Hull,	68
Springfield,	424	Danvers,	54
Salem,	375	Insane Hospital,	12
Newton,	373	Medway,	66
Quincy,	360	Peabody,	66
Chelsea,	350	Hopedale,	60
Waltham,	189	Rockland,	58
Hospital,	125	Randolph,	57
Malden,	288	Dedham,	54
Brockton,	256	Warren,	49
Holyoke,	225	Clinton,	48
Weymouth,	221	Marblehead,	48
Pittsfield,	199	Sherborn,	48
Winthrop,	174	Amesbury,	45
Fort Banks,	6	Watertown,	45
Everett,	172	Belmont,	42
Medford,	168	Concord,	36
Hyde Park,	167	Massachusetts Reformatory,	6
Reading,	162	Leominster,	42
North Adams,	132	Natick,	42
Fitchburg,	124	Revere,	42
Easton,	122	Woburn,	42
Framingham,	121	Stoughton,	39
Milton,	115	Adams,	36
Winchester,	112	Hudson,	36
Milford,	108	Lenox,	36
Chicopee,	96	Medfield,	36
Newburyport,	90	Norwood,	36
Braintree,	89	Plymouth,	36
Palmer,	78	Scituate,	36
Massachusetts Hospital for Epileptics,	6	Wellesley,	36

Number of Bottles of Diphtheria Antitoxin distributed from April 1, 1902, to March 31, 1903 — Continued.

City or Town.	Number of Bottles.	City or Town.	Number of Bottles.
Lexington,	34	Princeton,	11
Dighton,	33	Ayer,	9
Spencer,	33	Hanover,	9
Southbridge,	32	Kingston,	9
Maynard,	30	Whitman,	9
Methuen,	30	Southborough,	8
Middleborough,	30	Abington,	6
Millbury,	30	Agawam,	6
Needham,	30	Bedford,	6
North Brookfield,	30	Brookfield,	6
Stoneham,	30	Cheshire,	6
Williamstown,	28	Falmouth,	6
Arlington,	24	Hardwick,	6
Wilbraham,	24	Hingham,	6
Attleborough,	18	Hinsdale,	6
Cohasset,	18	Holbrook,	6
Holliston,	18	Jefferson,	6
Monson,	18	Marshfield,	6
North Andover,	18	Millis,	6
Rockport,	18	Nantucket,	6
South Hadley,	18	Northampton,	6
Swampscott,	18	Pepperell,	6
Webster,	18	Provincetown,	6
West Springfield,	18	Shirley,	6
Acton,	12	Southampton,	6
Avon,	12	Sterling,	6
Bellingham,	12	Swansea,	6
Beverly,	12	Templeton,	6
Douglas,	12	Tisbury,	6
Dover,	12	Ware,	6
East Bridgewater,	12	Wareham,	6
Foxborough,	12	West Boylston,	6
Gardner,	12	Westport,	6
Hopkinton,	12	Williamsburg,	6
North Attleborough,	12	Worthington,	6
Saugus,	12	Mattapoisett,	5
Westfield,	12	Lincoln,	4

Number of Bottles of Diphtheria Antitoxin distributed from April 1, 1902, to March 31, 1903 — Concluded.

City or Town.	Number of Bottles.	City or Town.	Number of Bottles.
Blandford,	3	Walpole,	3
Dudley,	3	Westford,	3
Edgartown,	3	Norton,	2
Leicester,	3	Total,	33,475
Merrimac,	3		

From the foregoing list it appears that the number of packages of antitoxin used in 1902 was less by 6,736 than the number used in the preceding year, and less by 19,914 than were used in 1900, the difference being due to the difference in the prevalence of diphtheria in these years. The number of cities and towns in which more than 100 bottles were used in each was 35, the same as in the previous year, but the average number used in each of these cities and towns was considerably less in 1902.

SUMMARY OBSERVATIONS UPON THE USE OF DIPHTHERIA ANTITOXIN IN MASSACHUSETTS DURING THE YEAR ENDED MARCH 31, 1903.

The whole number of returns of cases treated with diphtheria antitoxin furnished by the State Board of Health during the year ended March 31, 1903, to hospitals and to local boards of health for use in general practice was 2,149. Of this number, 1,979 were returns of cases of diphtheria treated with antitoxin, and 170 were returns of other persons who had been exposed to infection and were treated for the purpose of immunization. These cases constitute only a fraction of those which were treated during the year in the State with antitoxin furnished by the Board, since very many physicians failed to make returns to the Board.

Cases in which a Bacterial Examination was made.

The same methods of classification are continued in this report as were adopted in the reports of the previous seven years. The cases in which cultures were made are classified into positive and negative cases. Diagnostic examinations were made in 1,632 cases reported to the Board as having been treated with antitoxin, and of these, 1,401 proved to be genuine cases of diphtheria and 231 gave a negative result.

Positive Cases.

Of the 1,401 positive cases, or those in which a diagnosis of diphtheria was made by bacterial cultures from the throat of the patient, there were 1,263 recoveries and 138 deaths, or 9.8 per cent., the results of the previous years having been, respectively, 13.7, 11.6, 8.2, 7.9, 11.4, 9.4 and 10.1 per cent.

Sex. — The number of males was 670 and the deaths of these were 69, or 10.3 per cent. The females were 731, and the deaths of these were 69, or 9.4 per cent.

Ages. — The following table shows the cases and deaths by ages : —

Year ended March 31, 1903.

Age Periods.	Cases.	Deaths.	Fatality (Per Cent.).	
			1902.	1901.
From 0 to 2 years,	115	31	26.9	20.2
From 2 to 5 years,	341	40	11.7	14.0
From 5 to 10 years,	399	33	8.3	8.6
Over 10 years,	502	25	5.0	2.7
Age unknown,	44	9	20.5	12.3
	1,401	138	9.8	10.1

Day of Illness when Antitoxin was first administered. — The following table presents the fatality, according to the day of illness on which the antitoxin was first administered : —

Day.	Cases.	Deaths.	Fatality (Per Cent.).							
			1902.	1901.	1900.	1899.	1898.	1897.	1896.	1895.
First,	144	14	9.8	9.5	6.4	9.8	8.2	8.0	0.0	0.0
Second,	392	26	6.7	6.7	6.0	5.6	1.8	8.9	9.5	9.7
Third,	364	20	5.5	9.4	7.7	12.8	6.2	7.0	8.3	8.7
Fourth,	182	23	12.7	12.5	11.3	14.1	13.2	3.0	22.7	15.4
Fifth,	80	15	19.0	17.0	14.8	15.6	11.8	11.8	0.0	22.2
Sixth,	62	11	18.0	16.0	21.1	17.9	20.0	0.0	14.3	20.0
Seventh,	26	4	15.4	18.4	13.7	27.1	9.5	30.0	25.0	33.3*
Eighth and later,	74	13	17.8	18.5	16.8	14.7	10.4	13.6	16.6	–
Unknown,	77	12	–	–	–	–	–	–	–	–

* Seventh day and later.

The value of the foregoing table consists mainly in the definite statement of the fatality of cases according to the day of illness at which antitoxin treatment was begun. In general, it shows that the ratio of success in treatment depends largely upon the early date at which antitoxin is first administered. A fuller and more conclusive summary, embracing the whole period of eight years and containing greater numbers, may be found on a later page.

The cases in which antitoxin treatment was begun either upon the first, second or third days of illness constituted 64 per cent. of the whole number of positive cases reported to the Board to which antitoxin was administered during the year under consideration.

Hospitals and Private Practice.

	Cases.	Deaths.	Fatality (Per Cent.).
In hospitals, ...	1,003	112	11.2*
In private practice, ...	398	26	6.5*

* This apparent difference in the fatality of hospital and of general or outside treatment with antitoxin is accounted for by the fact that a considerable number of severe and fatal cases of diphtheria, which were treated by physicians in general practice, were reported as having been transferred to a hospital after one or more days of home treatment and died at the hospital.

Seasons of the Year. — The cases embraced in the foregoing enumeration occurred in the following order: —

Months.	Cases.	Deaths.	Months.	Cases.	Deaths.
1902.			1902.		
April, ...	127	13	October, ...	153	11
May, ...	115	15	November, . . .	171	12
June, ...	111	12	December, . . .	109	17
July, ...	80	9	1903.		
August, ...	87	6	January, . . .	117	11
September, ...	108	10	February, . . .	106	10
			March, ...	113	12
Total six months, .	628	65	Total six months, .	769	73

By the foregoing table it appears that there were 628 positive cases reported in the warmer months, with 65 deaths, and 769 cases in the colder months, with 73 deaths. In 4 cases the date was not given.

Negative Cases.

The reported cases in which a negative result was obtained were 231; and the deaths of these were 16, or 6.9 per cent.

Sex. — The males were 109, with 11 deaths, or 10.1 per cent., and the females 122, with 5 deaths, or 4.1 per cent.

Age. — The percentage of fatality at each of four age periods was as follows: 0 to 2 years, 31.2 per cent.; 2 to 5 years, 14.8 per cent.; 5 to 10 years, 1.8 per cent.; and none over 10 years.

SUMMARY OF THE EIGHT YEARS ENDED MARCH 31, 1903.

Positive Cases treated with Antitoxin.

Whole number of positive cases for the eight years, 11,555; deaths, 1,148; fatality, 9.9 per cent.

Sex. — The fatality by sexes was as follows: —

SEX.	Cases.	Deaths.	Fatality (Per Cent.).
Males, ...	5,444	577	10.6
Females, ...	6,021	555	9.2

The sex of 90 was not stated; 16 deaths.

Ages. — The fatality by ages was as follows: —

AGE PERIODS.	Cases.	Deaths.	Fatality (Per Cent.).
0 to 2 years, ...	1,284	285	22.2
2 to 5 years, ...	3,656	463	12.7
5 to 10 years, ...	3,362	242	7.2
Over 10 years, ...	2,898	109	3.8
Age unknown, ...	355	49	–

Hospitals and Private Practice.

	Cases.	Deaths.	Fatality (Per Cent.).
In hospitals, ...	8,131	890	10.9
In private practice, ...	3,424	255	7.4

Cases in which no Bacteriological Examination was made during the Year ended March 31, 1903.

Reports were received of 347 cases where antitoxin was employed in which no cultures were taken. Of this number, 289, or 83.3 per cent., occurred in general practice and the remainder were reported from hospitals. Of the whole number, 49 proved fatal, or 14.1 per cent.

Sex. — The number of males in this class was 152, and the deaths of these were 26, or 17.1 per cent. The number of females was 194, and the deaths of these were 23, or 11.8 per cent. The number of those whose sex was unknown or not stated was 1.

Age. — The following table presents the cases and fatality by ages among this class so far as observations were made: —

Age Periods.	Cases.	Deaths.	Fatality (Per Cent.).
From 0 to 2 years, ...	38	11	29.0
From 2 to 5 years, ...	94	19	20.2
From 5 to 10 years, ...	104	15	14.4
Over 10 years, ...	109	4	3.7
Age unknown, ...	5	0	–

The higher fatality of this class is explained by the fact that many of the cases embraced in the returns are described as "moribund" or "beyond help" or "in extremis" when antitoxin was administered. They were consequently beyond the reach of remedial aid, and in many of them it was impracticable to make a bacterial diagnosis.

SEQUELÆ.

Temporary skin eruptions, usually of brief duration, are of very common occurrence after the administration of antitoxin. Frequently these eruptions are quite mild and confined to a small area adjoining the place of injection, while occasional instances occur in which the eruption spreads throughout the entire surface of the body, or at least a portion of its area.

During the year under consideration such eruptions or rashes are reported as occurring in 672 instances, or 33.9 per cent. of the whole number reported upon. Of this number, 87 per cent. were mild in character and the remainder severe or extensive.

Albuminuria was reported in 195 instances, of which 89 per cent. were slight, or consisted of a trace only. The presence of albuminuria, however, has no significance as relating to the administration of antitoxin, since albuminuria is present according to good authorities in the majority of severe cases of diphtheria.*

OPERATIONS.

Tracheotomy, an operation which was once quite commonly resorted to in severe cases of laryngeal diphtheria, appears to have been largely supplanted by the more safe and simple operation of intubation. It is reported as having been performed 20 times during the year, with 16 deaths.

Intubation is reported as having been performed 148 times during the year, with 50 deaths, or 33.8 per cent., a greater fatality than that of the previous year.

The different diseases which are met with as complications of diphtheria independently of the use of antitoxin appear to depend for their frequency largely upon the relative prevalence of these diseases throughout the State. Scarlet fever and measles having been more or less prevalent in 1902, these diseases were occasionally met with in the hospitals as complications with diphtheria. Scarlet fever was reported as a complication in 99 instances and measles in 19. In most instances the complication adds to the severity of the cases and increases the fatality, but not to so great an extent as when pneumonia supervenes. Pneumonia and broncho-pneumonia were reported as complications in 28 cases, of which there were 18 deaths.

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* Osler's "Practice of Medicine," 2d edition, page 115.

The most important lesson, repeated in former reports, to which the experience of each successive year adds emphasis, is the necessity of the early administration of antitoxin in each and every case.

IMMUNIZATION.

Returns of cases in which antitoxin had been used for the purpose of the immunization of persons who had been exposed to the infection of diphtheria were received in 170 cases, 69 in hospital and 101 in general practice. Undoubtedly it was used in a considerably larger number of instances for this purpose, but returns were not made. The average dose employed for this purpose was about 900 units.

GENERAL SUMMARY, 1895–1902.

Positive cases treated in the eight years ending March 31, 1903, and reported to the State Board of Health,	11,555
Cases in which no bacteriological examination was made,	2,923
Total,	14,478*
Deaths of these,	1,516
Fatality (per cent.),	10.5

Sexes.

The number of males who were treated was †	6,755
The number of females who were treated was †	7,560
The number whose sex was not stated was †	163
Total,	14,478*
Deaths of males,	755
Fatality of males (per cent.),	11.2
Deaths of females,	736
Fatality of females (per cent.),	9.1
Deaths, sex not stated,	25

The following table contains the results of those cases only which had been determined by a culture examination to be positive, with reference to the fatality of the disease in each group of cases, considered in relation to the stage of the disease when antitoxin was first administered.

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* In this number (14,478) 1,470 cases in which a bacterial diagnosis showed negative results are not included, so that the whole number treated with antitoxin of which returns were made to the Board was 15,948.

† Except cases determined to be "negative."

Nothing can be more conclusive than the cumulative testimony of these figures, supported as they are by similar experience elsewhere, as to the importance of the earliest possible administration of antitoxin in the treatment of diphtheria. Each day's delay renders the liability to a fatal result greater.

The fatality of the cases which were treated with antitoxin very early in the course of the disease (that is, before the termination of forty-eight hours from its onset) was only 6.7* per cent., or 317 deaths in 4,717 cases, while that of the cases which were not thus treated until the sixth day or later was as high as 17.6 per cent., or nearly three times as great.

Day of Administration.

DAY.	Cases.	Deaths.	Fatality (Per Cent.).
First,	1,433	114	7.9
Second,	3,284	203	6.2
Third,	2,654	239	9.0
Fourth,	1,687	218	12.9
Fifth,	864	137	15.9
Sixth and later,	1,242	220	17.6

A considerable number of cases and deaths, in which the day of administration was not stated in the returns, is excluded from this table.

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* The sum of the experience of the first two days is expressed in this figure.

DIPHTHERIA CULTURES EXAMINED DURING THE YEAR ENDED MARCH 31, 1903.

During the year ended March 31, 1903, 2,904 cultures have been received from 123 towns and cities in the State. Of these cultures 1,267 were made for the purpose of diagnosis and 1,637 for release from quarantine. The following table gives the number of cultures received from the different towns and cities and the results of the examinations: —

CITY OR TOWN.	Whole Number of Cultures examined.	CULTURES EXAMINED FOR DIAGNOSIS.			Cultures examined for Release from Quarantine.
		Positive.	Negative.	Doubtful.	
Abington,	1	–	–	–	1
Adams,	1	–	–	1	–
Andover,	8	3	5	–	–
Arlington,	15	3	4	–	8
Attleborough,	1	–	–	–	1
Avon,	4	2	1	–	1
Barnstable,	1	–	1	–	–
Belmont,	1	1	–	–	–
Berlin,	1	1	–	–	–
Beverly,	13	1	9	–	3
Bolton,	1	–	1	–	–
Boston,	2	1	1	–	–
Bourne,	2	2	–	–	–
Braintree,	17	5	4	–	8
Bridgewater,	3	–	1	–	2
Brookfield,	1	–	–	–	1
Brookline,	1	1	–	–	–
Chelsea,	61	17	19	–	25
Cheshire,	1	–	1	–	–
Clinton,	15	1	7	–	7
Cohasset,	17	3	5	–	9
Concord,	23	5	7	–	11
Danvers,	32	7	10	–	15
Dedham,	7	2	2	–	3
Dighton,	1	–	–	–	1
Dover,	3	–	2	–	1
Duxbury,	6	1	4	–	1
Everett,	200	32	37	1	130
East Bridgewater,	3	–	3	–	–

City or Town.	Whole Number of Cultures examined.	Cultures examined for Diagnosis.			Cultures examined for Release from Quarantine.
		Positive.	Negative.	Doubtful.	
Easton,	149	16	17	–	116
Falmouth,	3	–	1	–	2
Foxborough,	12	–	12	–	–
Framingham,	15	6	3	–	6
Gloucester,	19	14	4	1	–
Great Barrington,	1	–	1	–	–
Groton,	5	1	2	–	2
Groveland,	1	1	–	–	–
Hanover,	1	–	1	–	–
Harvard,	1	–	1	–	–
Haverhill,	13	3	7	1	2
Hingham,	6	–	4	–	2
Holbrook,	2	1	1	–	–
Hopedale,	1	–	1	–	–
Hopkinton,	4	1	–	–	3
Hull,	3	–	3	–	–
Hyde Park,	79	5	11	–	63
Ipswich,	12	2	8	–	2
Kingston,	1	1	–	–	–
Lawrence,	21	5	15	–	1
Leominster,	14	2	11	1	–
Lexington,	11	1	5	–	5
Ludlow,	2	1	–	–	1
Lynn,	3	1	–	–	2
Malden,	263	32	39	2	190
Mansfield,	1	–	1	–	–
Marblehead,	31	7	17	–	7
Marlborough,	415	59	38	–	318
Marshfield,	1	–	–	–	1
Medfield,	28	3	4	–	21
Medford,	110	21	41	–	48
Medway,	6	2	1	–	3
Melrose,	84	6	18	2	58
Middleborough,	6	1	1	–	4
Milford,	2	2	–	–	–
Millis,	2	–	2	–	–
Milton,	127	19	46	–	62
Monson,	1	–	1	–	–
Nantucket,	1	1	–	–	–
Natick,	12	2	4	–	6
Needham,	5	–	4	–	1
Newbury,	1	–	1	–	–
Newburyport,	56	15	35	–	6
North Adams,	54	19	9	–	26
North Attleborough,	5	1	1	–	3
Norton,	1	–	1	–	–
Norwell,	4	2	–	–	2
Norwood,	5	1	3	–	1
Orange,	1	–	1	–	–
Palmer,	2	–	2	–	–
Peabody,	27	4	8	–	15

City or Town.	Whole Number of Cultures examined.	Cultures examined for Diagnosis.			Cultures examined for Release from Quarantine.
		Positive.	Negative.	Doubtful.	
Pittsfield,	36	5	15	–	16
Plymouth,	6	3	–	–	3
Princeton,	1	1	–	–	–
Quincy,	83	14	29	–	40
Randolph,	6	2	4	–	–
Reading,	66	11	28	–	27
Revere,	12	2	7	1	2
Rockland,	29	5	7	–	17
Rockport,	12	1	3	–	8
Salem,	137	25	20	–	92
Salisbury,	2	1	1	–	–
Saugus,	8	–	1	–	7
Scituate,	9	2	2	–	5
Sherborn,	1	1	–	–	–
Shirley,	2	–	2	–	–
Somerville,	81	17	24	–	40
Southborough,	2	–	2	–	–
Southbridge,	4	2	1	–	1
Spencer,	1	–	1	–	–
Stoneham,	5	2	3	–	–
Stoughton,	44	7	8	–	29
Swampscott,	10	2	6	2	–
Taunton,	1	–	–	–	1
Templeton,	1	1	–	–	–
Tisbury,	1	–	1	–	–
Wakefield,	12	–	6	–	6
Walpole,	5	–	4	–	1
Warren,	12	3	6	–	3
Wellesley,	18	2	4	–	12
Westborough,	8	1	5	–	2
West Bridgewater,	1	–	–	–	1
Westford,	2	–	1	–	1
Westport,	1	–	1	–	–
West Newbury,	2	–	–	–	2
Westwood,	2	1	–	–	1
Weymouth,	5	3	–	1	1
Williamstown,	2	1	1	–	–
Wilmington,	6	–	4	1	1
Winchester,	66	6	24	1	35
Winthrop,	101	15	17	1	68
Woburn,	23	3	14	1	5
Worthington,	4	1	–	–	3
Wrentham,	2	–	2	–	–
Total,	2,904	486	764	17	1,637

PERSISTENCE OF DIPHTHERIA IN THE THROATS OF PATIENTS CONVALESCENT OF DIPHTHERIA.

Among these cases are included only those in which frequent cultures were made until the throat was free from the bacilli. The time of persistence is given from the date of the earliest symptoms to when the bacilli were last found in cultures from the throat.

TIME OF PERSISTENCE.	Number of Cases.	TIME OF PERSISTENCE.	Number of Cases.
1 week or less, ...	16	8 to 9 weeks, ...	9
1 to 2 weeks, ...	105	9 to 10 weeks, ...	1
2 to 3 weeks, ...	179	10 to 11 weeks, ...	0
3 to 4 weeks, ...	150	11 to 12 weeks, ...	0
4 to 5 weeks, ...	111	12 to 13 weeks, ...	1
5 to 6 weeks, ...	58	13 to 14 weeks, ...	0
6 to 7 weeks, ...	25	14 to 15 weeks, ...	1
7 to 8 weeks, ...	15		

Relation of Clinical to Bacteriological Diagnosis.

CLINICAL DIAGNOSIS.	BACTERIOLOGICAL DIAGNOSIS.		
	Positive.	Negative.	Doubtful.
Positive in 415 cases, ...	255	156	4
Negative in 291 cases, ...	37	251	3
Doubtful in 368 cases, ...	122	242	4
Not given in 193 cases, ...	72	115	6
Total, ...	486	764	17

Relation of Bacteriological Diagnosis to the Day of Taking of Culture.

DAY OF DISEASE ON WHICH CULTURE WAS TAKEN.	BACTERIOLOGICAL DIAGNOSIS.			Percentage of Positive Cases.
	Positive.	Negative.	Doubtful.	
First day, ...	27	41	–	39.7
Second day, ...	146	259	2	35.9
Third day, ...	136	209	6	38.7
Fourth day, ...	61	95	3	38.4
Fifth day, ...	39	58	3	39.0
Sixth day, ...	13	25	–	34.2
Seventh day, ...	8	15	1	33.3
Over seven days, ...	26	21	–	55.3
Not stated, ...	30	41	2	41.1
Total, ...	486	764	17	38.4

SUMMARY OF THE SEVEN YEARS ENDED MARCH 31, 1903.

The whole number of cultures examined during the seven years is as follows: —

In 1896-97 (year ended March 31, 1897),	1,469
In 1897–98 (year ended March 31, 1898),	2,204
In 1898–99 (year ended March 31, 1899),	1,591
In 1899–1900 (year ended March 31, 1900),	3,258
In 1900–1901 (year ended March 31, 1901),	5,173
In 1901–1902 (year ended March 31, 1902),	4,119
In 1902–1903 (year ended March 31, 1903),	2,904
Total,	20,718

Of these 20,718 cultures, 9,568 were made for the purpose of diagnosis and 11,150 for release from quarantine. Of the cultures made for diagnosis 4,046 were positive, 5,364 were negative and 158 were doubtful.

In 2,101 cases, in which frequent cultures were made until the throat was free from the bacilli of diphtheria, the average time of persistence of the bacilli from the date of earliest symptoms was 25.2 days.

In 9,568 cultures examined for diagnosis the relation of clinical to bacteriological diagnosis was as follows: —

Clinical Diagnosis.	Bacteriological Diagnosis.		
	Positive.	Negative.	Doubtful.
Positive in 3,496 cases,	2,225	1,227	44
Negative in 1,948 cases,	369	1,546	33
Doubtful in 2,447 cases,	832	1,577	38
Not given in 1,677 cases,	624	1,013	40

EXAMINATION OF SPUTUM AND OTHER MATERIAL SUSPECTED OF CONTAINING THE BACILLI OF TUBERCULOSIS.

During the year ended March 31, 1903, microscopical examination has been made of 928 specimens of sputum and other material suspected of containing the bacilli of tuberculosis. This material was received from 121 different towns and cities in the State. The following table gives the places from which the material was received and the results of the examinations: —

City or Town.	Number of Cases examined.	Males.			Females.			Sex not stated.		
		Positive.	Negative.	Doubtful.	Positive.	Negative.	Doubtful.	Positive.	Negative.	Doubtful.
Abington,	2	–	1	–	–	1	–	–	–	–
Acton,	3	–	1	–	–	1	–	1	–	–
Adams,	3	1	1	–	–	1	–	–	–	–
Andover,	1	–	–	–	1	–	–	–	–	–
Arlington,	11	–	1	–	1	6	–	1	2	–
Ashland,	3	1	–	–	–	1	–	–	1	–
Athol,	1	1	–	–	–	–	–	–	–	–
Attleborough,	11	2	3	–	1	4	–	–	1	–
Avon,	2	1	–	1	–	–	–	–	–	–
Barnstable,	4	2	–	–	1	1	–	–	–	–
Bedford,	1	–	1	–	–	–	–	–	–	–
Belmont,	1	–	–	–	–	1	–	–	–	–
Blackstone,	4	1	–	–	1	2	–	–	–	–
Bolton,	4	–	1	–	–	–	–	3	–	–
Boston,	18	4	10	–	–	4	–	–	–	–
Boylston,	1	–	–	–	1	–	–	–	–	–
Bridgewater,	4	–	–	–	2	1	–	1	–	–
Brockton,	1	1	–	–	–	–	–	–	–	–
Brookfield,	8	–	3	–	1	4	–	–	–	–
Brookline,	1	1	–	–	–	–	–	–	–	–
Cambridge,	2	–	2	–	–	–	–	–	–	–
Chelmsford,	3	1	1	–	–	1	–	–	–	–
Chelsea,	6	–	1	–	1	3	–	–	1	–
Cheshire,	1	–	–	–	–	1	–	–	–	–
Clinton,	14	2	6	–	2	3	–	1	–	–
Cohasset,	1	–	–	–	–	1	–	–	–	–

City or Town.	Number of Cases examined.	Males.			Females.			Sex not stated.		
		Positive.	Negative.	Doubtful.	Positive.	Negative.	Doubtful.	Positive.	Negative.	Doubtful.
Colrain,	1	–	–	–	–	1	–	–	–	–
Concord,	13	3	5	–	3	2	–	–	–	–
Cottage City,	1	–	–	–	–	1	–	–	–	–
Danvers,	5	–	2	–	–	2	–	–	1	–
Dedham,	6	2	1	–	1	2	–	–	–	–
Douglas,	1	–	–	–	1	–	–	–	–	–
Everett,	43	10	9	1	10	13	–	–	–	–
East Bridgewater,	4	–	1	–	2	1	–	–	–	–
Edgartown,	2	–	–	–	–	2	–	–	–	–
Fall River,	115	30	29	–	22	30	1	2	1	–
Foxborough,	23	2	7	–	4	9	–	–	1	–
Framingham,	14	1	3	–	1	9	–	–	–	–
Franklin,	4	1	–	–	2	1	–	–	–	–
Gardner,	1	1	–	–	–	–	–	–	–	–
Gloucester,	3	1	2	–	–	–	–	–	–	–
Great Barrington,	1	–	1	–	–	–	–	–	–	–
Greenfield,	9	3	2	–	–	4	–	–	–	–
Hanson,	1	–	–	–	–	1	–	–	–	–
Haverhill,	7	–	2	–	1	3	–	–	1	–
Hingham,	10	6	1	–	–	3	–	–	–	–
Hubbardston,	1	–	1	–	–	–	–	–	–	–
Hudson,	1	1	–	–	–	–	–	–	–	–
Hyde Park,	2	1	1	–	–	–	–	–	–	–
Holbrook,	1	–	–	–	1	–	–	–	–	–
Lakeville,	2	–	1	–	–	1	–	–	–	–
Lawrence,	21	4	6	–	5	5	–	–	1	–
Lexington,	4	1	–	–	–	1	–	1	1	–
Littleton,	1	–	–	–	1	–	–	–	–	–
Lynn,	6	1	2	–	–	3	–	–	–	–
Lynnfield,	2	–	2	–	–	–	–	–	–	–
Malden,	21	5	3	–	3	9	–	–	1	–
Mansfield,	4	–	–	–	–	4	–	–	–	–
Marlborough,	11	–	3	–	–	8	–	–	–	–
Maynard,	2	–	1	–	1	–	–	–	–	–
Medford,	21	2	7	–	2	9	–	1	–	–
Medway,	7	5	1	–	–	1	–	–	–	–
Melrose,	30	4	7	–	10	9	–	–	–	–
Methuen,	5	–	2	–	–	3	–	–	–	–
Middleborough,	7	–	5	–	1	1	–	–	–	–
Milford,	1	–	–	–	–	–	–	–	1	–
Milton,	7	–	1	–	1	4	–	–	1	–
Millis,	1	–	1	–	–	–	–	–	–	–
Monson,	2	2	–	–	–	–	–	–	–	–
Nantucket,	1	–	1	–	–	–	–	–	–	–
Natick,	3	1	1	–	–	–	–	–	1	–
Needham,	5	–	1	–	–	4	–	–	–	–
New Bedford,	2	1	–	–	–	1	–	–	–	–
Newbury,	2	–	–	–	–	1	1	–	–	–
Newburyport,	3	1	–	–	–	2	–	–	–	–
Newton,	1	–	1	–	–	–	–	–	–	–

City or Town.	Number of Cases examined.	Males.			Females.			Sex not stated.		
		Positive.	Negative.	Doubtful.	Positive.	Negative.	Doubtful.	Positive.	Negative.	Doubtful.
North Adams,	61	16	18	–	9	15	–	2	1	–
North Andover,	2	–	1	–	1	–	–	–	–	–
North Attleborough,	14	3	5	–	4	2	–	–	–	–
North Brookfield,	1	–	–	–	1	–	–	–	–	–
Norwood,	6	1	–	–	1	1	–	2	1	–
Palmer,	6	1	2	–	1	2	–	–	–	–
Peabody,	25	3	6	–	7	9	–	-	–	–
Pittsfield,	2	–	–	–	–	2	–	–	–	–
Quincy,	30	2	11	–	5	11	–	1	–	–
Randolph,	15	1	5	–	4	3	–	1	1	–
Reading,	8	–	7	–	–	1	–	–	–	–
Revere,	12	3	4	–	2	3	–	–	–	–
Rockland,	12	2	7	–	1	2	–	–	–	–
Russell,	2	–	–	–	–	2	–	–	–	–
Salem,	35	8	6	–	7	14	–	–	–	–
Somerville,	17	2	2	–	3	9	–	–	1	–
Southborough,	1	–	1	–	–	–	–	–	–	–
Southbridge,	1	–	–	–	–	–	–	–	1	–
Southampton,	1	–	1	–	–	–	–	–	–	–
Spencer,	6	2	3	–	–	1	–	–	–	–
Stoughton,	1	1	–	–	–	–	–	–	–	–
Swampscott,	2	1	1	–	–	–	–	–	–	–
Taunton,	13	3	6	–	1	2	–	–	1	–
Topsfield,	1	1	–	–	–	–	–	–	–	–
Tyngsborough,	1	1	–	–	–	–	–	–	–	–
Wakefield,	2	–	–	–	–	1	–	1	–	–
Walpole,	3	–	–	–	–	1	–	1	1	–
Warren,	4	–	1	–	–	3	–	–	–	–
Watertown,	5	1	2	–	2	–	–	–	–	–
Wellesley,	6	–	4	–	–	2	–	–	–	–
Wenham,	1	–	1	–	–	–	–	–	–	–
West Boylston,	2	–	–	–	–	1	–	1	–	–
Westborough,	1	–	–	–	–	1	–	–	–	–
Westford,	9	–	1	–	1	7	–	–	–	–
Weston,	2	1	1	–	–	–	–	–	–	–
Weymouth,	7	1	4	–	–	2	–	–	–	–
Whitman,	9	2	4	–	1	2	–	–	–	–
Williamstown,	4	–	1	–	2	1	–	–	–	–
Wilmington,	1	–	1	–	–	–	–	–	–	–
Winchendon,	6	3	–	–	1	2	–	–	–	–
Winchester,	16	2	5	–	4	3	–	–	2	–
Winthrop,	4	–	1	–	1	2	–	–	–	–
Woburn,	1	–	1	–	–	–	–	–	–	–
Worcester,	12	1	3	–	1	6	–	–	1	–
Worthington,	2	–	1	–	–	1	–	–	–	–
Place not stated,	4	–	1	–	1	–	–	–	2	–
Total,	928	169	263	2	145	300	2	20	27	–

Ages. — The relation of bacteriological diagnosis to age is shown in the following table: —

AGE PERIODS.	Number of Cases examined.	Positive.	Negative.	Doubtful.	Percentage of Positive Cases.
From 0 to 10 years,	19	2	17	–	10.5
From 10 to 20 years,	129	45	83	1	34.9
From 20 to 30 years,	277	110	167	–	39.7
From 30 to 40 years,	208	79	129	–	38.0
From 40 to 50 years,	115	41	72	2	35.7
From 50 to 60 years,	48	11	37	–	22.9
From 60 to 70 years,	29	7	21	1	24.1
From 70 to 80 years,	12	–	12	–	00.0
From 80 to 90 years,	2	–	2	–	00.0
Age not stated,	89	39	50	–	–
Total,	928	334	590	4	43.8

Sex. — The relation of bacteriological diagnosis to sex is shown in the following table: —

BACTERIOLOGICAL DIAGNOSIS.	Total.	Males.	Females.	Sex not stated.
Positive cases,	334	169	145	20
Negative cases,	590	263	300	27
Doubtful cases,	4	2	2	0
Total,	928	434	447	47

Clinical Diagnosis. — The relation of clinical diagnosis to bacteriological diagnosis is as follows: —

CLINICAL DIAGNOSIS.	BACTERIOLOGICAL DIAGNOSIS.		
	Positive.	Negative.	Doubtful.
Positive in 328 cases,	170	157	1
Negative in 145 cases,	25	119	1
Doubtful in 184 cases,	52	132	–
Not given in 271 cases,	87	182	2
Total in 928 cases,	334	590	4

Duration of Disease. — The relation of bacteriological diagnosis to the duration of the disease is shown below: —

Duration of Disease to the Time of Examination of Sputum.	Bacteriological Diagnosis.			Percentage of Positive Cases.
	Positive.	Negative.	Doubtful.	
1 month or less,	23	88	1	20.5
1 to 2 months,	40	78	–	33.9
2 to 3 months,	35	58	–	37.5
3 to 6 months,	60	78	–	43.5
6 to 9 months,	16	7	–	69.6
9 to 12 months,	38	32	–	54.3
1 to 2 years,	26	22	–	54.2
Over 2 years,	15	38	1	27.8
Not given,	81	189	2	29.8
Total,	334	590	4	35.9

SUMMARY OF THE SEVEN YEARS ENDED MARCH 31, 1903.

The number of specimens of sputum and other material examined for the bacilli of tuberculosis during the seven years ended March 31, 1903, is as follows: —

In 1896–1897 (year ended March 31, 1897),	124
In 1897–1898 (year ended March 31, 1898),	236
In 1898–1899 (year ended March 31, 1899),	414
In 1899–1900 (year ended March 31, 1900),	571
In 1900–1901 (year ended March 31, 1901),	746
In 1901–1902 (year ended March 31, 1902),	797
In 1902–1903 (year ended March 31, 1903),	928
Total,	3,816

Of these 3,816 specimens, 1,567, or 41.1 per cent., contained the bacilli of tuberculosis, in 2,199 specimens the bacilli were not found and in 50 specimens the bacteriological diagnosis was doubtful.

Ages. — Of 582 specimens from persons who were under twenty years of age 36.9 per cent. were positive; of the 2,435 specimens from persons who were between the ages of twenty and fifty years 44.2 per cent. were positive; and of the 423 specimens from persons who were over fifty years of age 22.9 per cent. were positive. The age was not given in 396 cases. Of the positive cases 213, or 13.6 per cent., were under twenty years of age, 1,081, or 68.9 per cent., were between twenty and fifty years of age, 97, or 6.2 per cent., were over fifty years of age, and in 176 the age was not stated.

Sex. — Of the 3,816 cases from which material was examined, 1,772 were males, 1,836 were females and the sex was not stated in 208. Of the male cases 42.3 per cent. and of the female cases 39.8 per cent. were positive.

TYPHOID FEVER.

WIDAL, AGGLUTINATIVE OR SERUM TEST.

During the year the method for collecting blood for the Widal or agglutinative test described in the report for 1900 continued to be used.

The blood specimens examined are given in the two following tables. In the first they are grouped according to towns. The whole number of specimens received is given and divided into positive and negative, according to the outcome of the test. Fifty-seven towns sent to the laboratory 217 specimens, of which 65 were positive and 152 negative.

In the second table the results of the examination are arranged according to the day of the disease on which the blood was collected. From this table it will be seen that positive cases are not encountered until the sixth day of the disease. Since the agglutination-reaction may not appear until the second week of the disease, or even later, the blood of cases examined with negative result during the first week should be again examined in the second or third week.

The discovery in different countries of a considerable number of cases of disease closely simulating typhoid fever, but responding negatively to the Widal test with typhoid bacilli, has led to the discovery of a group of bacilli, presumably the cause of these attacks, which resemble the typhoid bacillus but are readily distinguished from it by certain bio-chemical tests.

At present the laboratory is not in position to recognize such types of disease. In order to make a diagnosis it would be necessary to test a series of these so-called paratyphoid and paracolon bacilli with the blood, which would have to be sent in considerably larger amounts than is needed for the simple test with the typhoid bacillus.

Fortunately, these aberrant typhoid-like affections are milder than genuine typhoid and as a rule non-fatal.

Typhoid Fever (Widal Test).

CITY OR TOWN.	Number of Cases.	Positive.	Negative.	CITY OR TOWN.	Number of Cases.	Positive.	Negative.
Allston, ...	5	-	5	Boston, ...	5	3	2
Arlington, . . .	1	1	-	Cambridge, . . .	1	1	-
Attleborough, . .	1	1	-	Charlestown, . .	1	1	-
Barnstable, . . .	1	1	-	Chelmsford, . .	7	2	5

Typhoid Fever (Widal Test) — Concluded.

City or Town.	Number of Cases.	Positive.	Negative.	City or Town.	Number of Cases.	Positive.	Negative.
Chelsea,	6	1	5	Milton,	11	4	7
Concord,	4	–	4	Natick,	1	1	–
Cottage City,	1	–	1	Needham,	5	2	3
Danvers,	8	4	4	Newburyport,	26	10	16
Dedham,	1	–	1	Newton,	1	1	–
Duxbury,	3	1	2	Norwood,	6	3	3
Easton,	3	1	2	Quincy,	1	1	–
Edgartown,	1	1	–	Reading,	5	1	4
Everett,	7	1	6	Revere,	1	1	–
Fall River,	1	–	1	Salem,	4	–	4
Foxborough,	2	1	1	Scituate,	1	–	1
Groton,	1	–	1	Somerville,	16	4	12
Haverhill,	2	–	2	Southbridge,	1	1	–
Hingham,	1	–	1	Swampscott,	5	2	3
Holden,	1	1	–	Taunton,	1	–	1
Hyde Park,	8	2	6	Waltham,	2	1	1
Lowell,	1	–	1	Ware,	1	–	1
Lynn,	3	1	2	Wellesley,	3	–	3
Marblehead,	2	–	2	Westport,	1	–	1
Marlborough,	3	2	1	Winchester,	8	3	5
Marshfield,	1	1	–	Williamstown,	4	–	4
Medford,	6	–	6	Wilmington,	5	–	5
Medway,	1	–	1				
Melrose,	17	3	14	Total,	217	65	152
Middleborough,	2	–	2				

Widal Test, according to Stage of Disease.

Approximate Number of Days from Beginning of Disease to Collection of Blood.	Number of Cases.		Approximate Number of Days from Beginning of Disease to Collection of Blood.	Number of Cases.	
	Positive.	Negative.		Positive.	Negative.
1,	–	1	21,	–	8
2,	–	3	22,	1	–
3,	–	1	26,	–	2
4,	–	9	28,	–	3
5,	–	6	30,	–	2
6,	2	10	31,	1	–
7,	7	16	36,	1	2
8,	5	9	41,	2	2
9,	7	7	49,	–	1
10,	2	19	56,	–	1
11,	1	3	60,	1	–
12,	5	7	63,	–	1
13,	3	6	66,	1	–
14,	7	9	71,	1	–
15,	1	2	80,	1	–
16,	1	4	Unknown,	7	12
17,	4	2			
18,	2	2	Total,	65	152
20,	2	2			

MALARIA.

The number of blood films received by the laboratory during the current year for microscopic diagnosis was considerably lower than that of the year preceding. Of 61 preparations received only 17, or about 28 per cent., showed the malaria parasite.

This is evidence of a general reduction in the number of cases and of the reduced prevalence of the disease throughout the State, which may have been in part due to the cold and wet season.

Malaria.

City or Town.	Number of Cases.	Positive.	Negative.
Barnstable,	2	–	2
Bedford,	2	–	2
Boston,	19	9	10
Braintree,	1	–	1
Brockton,	1	–	1
Chelmsford,	5	–	5
Clinton,	5	3	2
Foxborough,	1	1	–
Medford,	1	–	1
Melrose,	5	2	3
Middleborough,	1	–	1
Norwood,	1	–	1
Uxbridge,	1	–	1
Waltham,	2	–	2
West Boylston,	1	–	1
Wilmington,	2	1	1
Winchester,	11	1	10
Total,	61	17	44

STATISTICAL SUMMARIES

OF

DISEASE AND MORTALITY.

STATISTICAL SUMMARIES OF DISEASE AND MORTALITY.

The statistical information relating to disease and mortality which has been received by the Board during each year, either through the medium of voluntary returns or in consequence of legal requirements, has, in the recent reports of the Board, been presented under four different heads or groups. In the present report this series of statistics has been condensed as much as can be done consistently with a clear and intelligent method of presentation.

These summaries are defined as follows: —

I. *The Weekly Mortality Returns.* — These consist of the reports of deaths, which are made up weekly and are sent to the office of the State Board by the registration officials of cities and towns. They are voluntary, and serve principally to show the seasonal prevalence of each of the chief infectious diseases, and the mortality of children under five years old in weekly periods. This series of statistics has been continued by the Board for more than twenty-five years, and has been published as a summary for nineteen years.

II. *The Reports of Certain Infectious Diseases, — Diphtheria and Croup, Scarlet Fever, Typhoid Fever and Measles.* — These are obtained from the annual reports of local boards of health for the year 1902, which are forwarded to the State Board from cities and towns. By comparing the numbers of reported cases with the reported deaths, the mean fatality of each disease in the places from which the reports are made is obtained with a reasonable degree of accuracy. This summary was first presented in the report of 1891, page 878.

III. *Reports of Cities and Towns, made under the Provisions of Chapter 75, Section 52, of the Revised Laws.* — By this act each local board of health is required to report to the State Board every case of "disease dangerous to the public health" which is reported to the local board. A digest of these reports is presented in Summary No. III. This summary was first published in the report of 1893, page 639.

IV. *Annual Reports made under the Provisions of Chapter 75, Section 12, of the Revised Laws.* — The full reports of deaths occurring in each city and town having over 5,000 inhabitants comprise another series of returns, which are summarized in No. IV. The population of these cities and towns in 1902 constituted about 85 per cent. of the estimated total population of the State. These reports are made under the requirements of the following statute: —

> In each city and town having a population of more than five thousand inhabitants, as determined by the last census, at least one member of said board shall be a physician, and the board shall send an annual report of the deaths in such town to the State Board of Health. The form of such reports shall be prescribed and furnished by the State Board of Health. (Revised Laws, chapter 75, section 12.)

This summary was first presented in the report of 1894.

NOTE. — A supply of the postal cards, necessary for the reporting of voluntary mortality returns such as are required for the data presented in section I. of the following summary, will be forwarded to the registration officers of any city or town who are willing to contribute the necessary information.

Postal cards are also sent to all boards of health in the State, for the purpose of aiding them to comply with the provisions of chapter 75, section 52, of the Revised Laws, relative to the reporting of diseases dangerous to the public health to the State Board immediately after reports of the same are received by the local board.

Annual blank forms are also sent to each local board of health in cities and towns having over 5,000 inhabitants, for the return of such information as is called for by the provisions of chapter 75, section 12, of the Revised Laws.

I.

THE WEEKLY MORTALITY RETURNS.

In the following summary, the voluntary reports of deaths received at the close of each week from the city registrars, town clerks and boards of health of the cities and towns are epitomized for the year 1902. The chief value of this abstract consists in the fact that it presents a continuous history of the mortality from certain specified diseases from week to week throughout the year.

This weekly report has been published in the Boston Medical and Surgical Journal every week for a period of twenty-five years or more, and also as a publication of the Board, in a weekly bulletin, since and including 1883.

These returns are necessarily incomplete, since they are voluntary and consequently embrace the statistics of a portion only of the population, the reporting places being chiefly the cities and large towns.

The estimated population of the cities and towns contributing to these returns in 1902 was 2,013,099, or nearly 70 per cent. of the estimated total population.

The following items are embraced in this summary: —

Average height of barometer for each week.
Mean maximum temperature.
Mean minimum temperature.
Rainfall, expressed in inches.
Total deaths reported for each week.
Deaths of children under five years.
Deaths from consumption.
Deaths from acute lung diseases.
Deaths from typhoid fever.
Deaths from diarrhœal diseases.
Deaths from scarlet fever.
Deaths from measles.
Deaths from diphtheria and croup.
Deaths from puerperal fever.
Deaths from whooping-cough.
Deaths from malarial fever.
Deaths from erysipelas.
Deaths from cerebro-spinal meningitis.

The following table contains a summary of the statistics compiled from these weekly returns of mortality: —

Summary for 1902.

1902.		Barometer.	Maximum Mean Thermometer for Each Week.	Minimum Mean Thermometer for Each Week.	Humidity.	Rainfall, in Inches.*	Total Deaths.	Deaths under Five Years of Age.	Consumption.	Acute Lung Diseases.	Typhoid Fever.	Diphtheria and Croup.	Scarlet Fever.	Measles.	Diarrhœal Diseases.	Whooping-cough.	Puerperal Fever.	Malarial Fever.	Erysipelas.	Cerebro-spinal Meningitis.
Jan.	4,	29.97	38	18	75	-	580	143	60	75	5	18	7	7	11	2	1	-	1	3
	11,	30.04	32	22	83	-	534	153	65	84	7	20	2	3	6	2	-	-	4	3
	18,	29.81	35	19	75	-	613	172	74	91	7	21	2	3	3	2	1	-	-	3
	25,	30.01	39	26	73	2.19	574	168	64	89	-	27	2	1	2	2	2	-	2	4
Feb.	1,	30.36	32	18	67	-	596	167	68	102	5	21	5	1	4	7	-	-	1	7
	8,	29.73	31	18	67	-	621	188	66	92	5	21	5	4	6	3	2	-	1	5
	15,	29.80	35	20	66	-	728	200	95	123	8	18	4	6	11	5	-	-	4	4
	22,	29.79	34	22	80	4.51	647	172	72	126	2	12	5	4	4	3	1	-	1	5
March	1,	29.92	45	33	89	-	647	174	66	99	5	21	4	1	6	3	-	-	3	4
	8,	29.89	44	32	69	-	594	158	57	116	3	12	2	9	10	4	-	-	3	7
	15,	30.12	51	36	75	-	634	192	65	102	4	16	4	6	10	4	2	-	5	9
	22,	29.87	51	36	78	-	636	167	69	102	5	7	-	6	18	4	1	1	2	3
	29,	30.07	51	39	73	5.56	575	164	65	100	7	8	11	5	5	2	2	-	1	6
April	5,	29.64	51	38	68	-	653	169	72	116	6	17	1	5	7	4	1	-	3	4
	12,	29.83	48	39	85	-	639	185	69	112	3	11	5	6	6	1	-	-	3	11
	19,	29.98	56	39	62	-	624	203	64	81	6	16	3	5	4	3	-	-	4	9
	26,	30.00	64	44	75	3.60	646	161	73	95	1	12	3	8	7	3	2	-	4	3
May	3,	30.04	64	49	64	-	665	184	76	96	3	22	5	4	14	1	-	-	3	6
	10,	29.96	64	45	63	-	661	175	72	103	9	14	6	4	11	1	-	-	3	6
	17,	30.07	64	45	56	-	622	140	66	92	5	13	2	7	9	1	-	-	2	3
	24,	28.98	74	53	67	-	662	169	69	103	3	9	2	7	8	5	-	-	2	6
	31,	29.88	69	52	75	1.83	586	175	53	79	3	9	5	11	14	5	2	-	3	8
June	7,	30.03	78	54	69	-	555	146	62	64	3	8	5	7	6	5	1	-	4	9
	14,	29.86	72	52	72	-	534	136	53	63	-	10	9	1	11	4	-	-	2	4
	21,	29.80	74	57	77	-	470	121	66	36	5	6	5	3	18	3	-	-	-	4
	28,	29.80	73	55	57	3.57	533	133	62	42	5	6	5	4	17	5	-	-	-	5
July	5,	29.95	72	58	70	-	524	167	40	47	2	8	2	2	43	1	1	-	1	2
	12,	30.04	80	61	68	-	667	241	55	40	6	7	2	4	79	7	1	-	3	9
	19,	29.92	80	62	67	-	652	301	50	27	6	7	5	3	133	5	-	-	-	8
	26,	30.04	64	58	91	3.44	739	330	65	45	4	8	4	3	163	7	-	1	2	6
Aug.	2,	30.01	78	64	78	-	694	309	56	28	5	7	4	1	152	7	-	1	-	8
	9,	29.83	78	64	79	-	666	305	32	20	6	7	2	2	124	4	-	-	1	5
	16,	29.97	76	58	63	-	635	304	50	35	5	5	7	1	143	7	1	-	-	3
	23,	29.87	70	57	76	-	671	320	54	35	5	7	2	2	175	7	-	-	1	7
	30,	30.09	75	60	75	3.21	620	249	47	31	8	6	3	3	91	8	-	-	-	7

Sept. 6,	30.04	78	59	71	-	630	247	58	28	12	7	5	-	92	13	3	-	1	5
13,	30.05	74	57	80	-	667	274	49	28	7	8	5	2	104	3	1	-	-	7
20,	30.27	64	54	82	-	622	246	51	28	13	7	5	1	109	4	-	1	2	5
27,	30.12	63	55	85	3.97	571	199	53	34	11	5	1	1	69	3	-	-	-	5
Oct. 4,	29.88	65	58	86	-	643	247	54	48	16	8	4	1	62	8	1	1	-	3
11,	29.99	66	48	72	-	624	241	61	53	14	16	5	2	63	5	-	-	1	4
18,	30.01	62	46	79	-	630	230	64	65	17	7	7	-	41	4	2	-	2	7
25,	30.17	60	43	77	5.04	645	215	60	64	12	13	9	2	37	6	-	-	1	6
Nov. 1,	30.17	54	38	70	-	654	235	48	102	8	21	9	-	33	8	-	-	2	3
8,	30.19	58	40	83	-	710	225	58	95	17	22	9	-	35	8	1	1	-	1
15,	30.16	60	37	83	-	628	179	61	88	7	18	6	1	16	3	-	-	1	7
22,	30.11	55	42	83	-	576	144	51	87	12	10	8	1	17	3	-	-	-	2
29,	29.81	46	33	71	1.30	649	211	56	94	12	11	5	2	17	8	-	-	1	3
Dec. 6,	29.91	42	28	78	-	642	184	68	94	11	19	8	2	10	8	-	-	-	6
13,	30.18	25	8	83	-	702	228	56	118	8	17	7	1	6	9	-	-	3	4
20,	30.16	40	25	77	-	724	231	69	148	11	17	6	3	10	5	-	-	1	5
27,	30.03	40	23	79	5.81	624	184	58	117	8	16	10	1	5	2	1	-	1	3
Totals,	-	-	-	-	44.03	32,638	10,561	3,167	3,962	358	659	249	169	2,057	237	30	6	85	272
Weekly average,	-	-	-	-	-	628	203	61	76	6.9	12.7	4.8	3.3	39.6	4.6	.6	.1	1.6	5.2
Rate per 1,000 deaths,	-	-	-	-	-	-	323.6	97.0	121.4	11.0	20.2	7.7	5.2	78.7	7.3	.92	.2	2.60	8.33
Rate per 1,000 population,	-	-	-	-	-	16.21	5.25	1.57	1.97	.18	.33	.12	.08	1.02	.12	.01	.003	.042	.13

Average reporting population, ... 2,013,099

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* Rainfall in inches. The figures in this column are given by months instead of weeks.

Condensed Statistics relative to the Total Deaths, Deaths under Five Years, and Deaths from Certain Causes in Reporting Cities and Towns of Massachusetts in 1902.

	Deaths.	Average Number of Deaths in Each Week.	Percentage of Total Mortality.	Death-rate per 1,000 of Reporting Population.
Total deaths,	32,638	628	100.0	16.21
Deaths under five years,	10,561	203	32.4	5.25
Deaths from consumption,	3,167	61	9.7	1.57
Deaths from acute lung diseases,	3,962	76	12.1	1.97
Deaths from diarrhœal diseases,	2,057	40	7.9	1.02
Deaths from typhoid fever,	358	7	1.1	.18
Deaths from diphtheria and croup,	659	13	2.0	.33
Deaths from scarlet fever,	249	4.8	.8	.12
Deaths from measles,	169	3.3	.5	.08
Deaths from cerebro-spinal meningitis,	272	5.2	.8	.13
Deaths from whooping-cough,	237	4.6	.7	.12
Deaths from puerperal fever,	30	.6	.09	.01
Deaths from erysipelas,	85	1.6	.26	.04
Deaths from malarial fever,	6	.1	.02	.003

The usual observations upon the weekly mortality statistics are omitted, and the foregoing short table, containing the essential statistics, supplies their place. The omission is made because information of the same character is presented in a different form in Section IV. of these summaries. The chief difference consists in the fact that the information given in this section (I.) is entirely voluntary and is detailed by weeks, while that of section IV. is required by statute, the data not being forwarded to the Board until after the close of the year. The population which furnishes the statistics presented in Section IV. is considerably larger than that embraced in Section I., but both populations consist of the more densely settled parts of the State.

Meteorology.

The principal points of sanitary interest in the meteorology of Massachusetts for the year 1902 were the following: —

The mean temperature for the year in Massachusetts was 48.2.

The summer was unusually cool, the mean temperature of each of the months of June, July, August and September being as follows: 61.3°, 67.2°, 66.4° and 62.4°. In each instance except in September the temperature was below the normal for the month.

The annual rainfall was 44.03 inches, or a little below the normal of a series of years.

II.

Fatality of Certain Diseases.

The following statement presents the statistics gathered from the published reports of local boards of health relative to the numbers of the cases and the deaths from each one of certain notifiable diseases. Its object is to present the fatality of these diseases (ratio of deaths to cases) from year to year.

The diseases embraced in this summary in 1902 are diphtheria, scarlet fever, typhoid fever, measles and small-pox.

The number of cities and towns contributing to this report is 93, or 29 more than those of 1901.

The tabular list of cities and towns is omitted in this report. The summary of the figures for 1902 is as follows: —

Reported cases of diphtheria and croup,	5,848
Registered deaths from diphtheria and croup in the same cities and towns,	666
Fatality (per cent.),	11.4
Reported cases of scarlet fever,	4,306
Registered deaths from scarlet fever in the same cities and towns,	251
Fatality (per cent.),	5.8
Reported cases of typhoid fever,	2,542
Registered deaths from typhoid fever in the same cities and towns,	383
Fatality (per cent.),	15.1
Reported cases of measles,	11,949
Registered deaths from measles in the same cities and towns,	162
Fatality (per cent.),	1.4
Reported cases of small-pox,	1,762
Registered deaths from small-pox in the same cities and towns,	255
Fatality (per cent.),	14.5

The reported cases of diphtheria were less by 3,073 than those of 1901, and were less than half as many as those reported in 1900. The number of deaths from the same cause was also less than those of 1901 by 272. The fatality was slightly in excess of that of 1901, but for the past three years has not exceeded 11.4 per cent. of the cases.

The reported cases of scarlet fever were 435 more than those of 1901, but the deaths were less by 73 than those of the preceding year. The fatality was 5.8 per cent., that of 1901 being 8.4.

The reported cases of typhoid fever were 264 more than those of 1901, but the deaths were 12 less, and the fatality was only 15.1 per cent., that of 1901 being 17.3 and the mean of twelve years 18.2. This fatality, 15.1, was the lowest of any year of record.

The reported cases of measles were greater in number than those of 1901 by 3,692, and the deaths exceeded those of 1901 by 14. The fatality, 1.4 per cent , was less than that of 1901 and but slightly greater than the mean of twelve years.

The following table presents the summary of these statistics for the twelve years 1891–1902: —

Reported Cases of Infectious Diseases in Massachusetts.

Diphtheria and Croup.

[Pre-Antitoxin Period.]

	1891.	1892.	1893.	1894.	Total.
Reported cases,	2,444	3,033	2,919	4,936	13,332
Deaths,	575	891	926	1,376	3,768
Fatality (per cent.),	23.5	29.2	31.7	27.9	28.3

Diphtheria and Croup.

[Antitoxin Period.]

	1895.	1896.	1897.	1898.	1899.	1900.	1901.	1902.	Total 1895-1902.
Reported cases,	7,856	8,915	7,856	3,843	6,540	12,578	8,921	5,848	62,307
Deaths,	1,484	1,348	1,107	507	758	1,274	938	666	8,082
Fatality (per cent.),	18.9	15.1	14.1	13.2	11.6	10.2	10.5	11.4	13.0

Scarlet Fever.

	1901.	1902.	Total 1891-1902.
Reported cases,	3,871	4,306	63,573
Deaths,	324	251	3,554
Fatality (per cent.),	8.4	5.8	5.6

Typhoid Fever.

Reported cases,	2,278	2,542	29,578
Deaths,	395	383	5,388
Fatality (per cent.),	17.3	15.1	18.2

Measles.

Reported cases,	8,257	11,949	89,841
Deaths,	148	162	1,124
Fatality (per cent.),	1.8	1.4	1.3

In the foregoing tables the statistics relating to diphtheria and croup have been arranged in two periods, which may properly be called the pre-antitoxin and the antitoxin periods, since antitoxin came into general use in the State about the beginning of the year 1895. The mean fatality in the former period (1891–94) was 28.3 per cent. (ratio of deaths to cases), and in the latter period (1895–1902) it was 13.0 per cent., or less than half as large.

In England, where systematic records have been kept in regard to the fatality of these diseases, the percentage of deaths to cases in diphtheria, as determined from 280,699 cases and 56,129 deaths which occurred in the period of twelve years (1890–1901) was 19.9. There was, however, a uniform diminution in this percentage, after the introduction of antitoxin treatment, from 25.1 in 1894 to 15.1 in 1901.

The fatality of scarlet fever showed quite similar figures to those of Massachusetts, the maximum being 8 per cent. in 1890 and the minimum 3.1 per cent. in 1899.

In typhoid fever the fatality varied also from 20.8 in 1891 to 15.1 in 1902.

The fatality of measles varied from a maximum of 4 per cent. in 1892 to a minimum of 0.7 in 1897.

III.

OFFICIAL RETURNS OF NOTIFIED DISEASES DANGEROUS TO THE PUBLIC HEALTH, 1902.

The figures presented in the following summary are those of the official returns of diseases "dangerous to the public health," made to the State Board of Health during the year 1902, under the provisions of chapter 75 of the Revised Laws. In this act no disease is specified as being "dangerous to the public health" except small-pox. Hence the State Board deemed it necessary to indicate the diseases which should be included in the meaning of the term "dangerous to the public health." They are the following: small-pox, scarlet fever, measles, typhoid fever, diphtheria, membranous croup, cholera, yellow fever, typhus fever, cerebro-spinal meningitis, hydrophobia, malignant pustule, leprosy and trichinosis.

The whole number of cases of infectious diseases reported to the Board in 1902, under the provisions of this act, was 33,933, which were divided as follows: —

Reported cases of small-pox,	2,314
Reported cases of scarlet fever,	4,613
Reported cases of diphtheria and croup,	7,036
Reported cases of typhoid fever,	2,721
Reported cases of measles,	17,249
Total,	33,933

The summary for the nine years 1893–1902 is as follows: —

	REPORTED CASES OF					Total.
	Small pox.	Diphtheria and Croup.	Scarlet Fever.	Typhoid Fever.	Measles.	
1893 (four months only),	35	1,109	2,914	1,525	1,503	7,086
1894,	181	4,178	6,731	2,372	2,133	15,595
1895,	1	7,806	6,194	2,438	4,868	21,307
1896,	5	8,515	3,801	2,637	6,362	21,320
1897,	18	7,613	5,495	2,104	12,695	27,925
1898,	10	3,980	3,667	2,196	4,478	14,331
1899,	105	7,134	5,349	2,776	12,355	27,719
1900,	104	12,641	6,396	2,967	10,507	32,615
1901,	773	9,793	4,356	2,689	9,398	27,009
1902,	2,314	7,036	4,613	2,721	17,249	33,933
Total,	3,546	69,805	49,516	24,435	81,548	228,840

By months these diseases were reported as follows: —

Cases of Infectious Diseases reported to the State Board of Health by Months in 1902.

MONTHS.	Small-pox.	Scarlet Fever.	Diphtheria.	Typhoid Fever.	Measles.
January, .	331	384	787	152	1,753
February, .	295	388	664	146	2,319
March, .	289	356	615	128	2,914
April,. .	236	388	544	111	2,418
May, . .	259	439	585	146	2,892
June, . .	163	356	486	122	1,763
July, . .	146	257	361	136	696
August, .	80	246	373	210	239
September,.	87	281	490	452	138
October, .	99	396	716	472	257
November, .	153	558	751	344	663
December, .	176	564	664	302	1,197
Total, .	2,314	4,613	7,036	2,721	17,249

The following table is introduced for the purpose of facilitating the comparison of the seasonal prevalence of the diseases named in the table, in different years. By means of the method employed the errors due to the difference in the length of the months are eliminated. The figures should be read as follows: For example, the mean daily number of reported cases of diphtheria reported throughout the year in 1902 was 19.3, of scarlet fever, 12.6, of typhoid fever, 7.4, and of measles 47.3. During the month of January the mean daily number of reported cases of these diseases was for diphtheria 25.4, scarlet fever, 12.4, typhoid fever, 4 9, and for measles, 56.5 (see columns marked A).

Assuming a standard of 10 as a daily mean throughout the year, the ratios for January were as follows: diphtheria, 13.2, scarlet fever, 9.8, typhoid fever, 6.6, and measles, 12.0 (see columns marked B). So that, for each 10 cases of diphtheria reported as a daily mean throughout the year 1902 there were 13.2 in January, 12.3 in February, 10 3 in March, etc.

From this table it appears that the maximum prevalence of diphtheria in 1902 was in January and the minimum in July, as in the preceding year. The prevalence in the last three months of the year was nearly the same as that of the first three months, while in the previous year there was a more decided fall in December. There has been in every one of the past eight years a decline in the prevalence of the disease in December, except in December, 1899.

The prevalence of scarlet fever was above the mean in February, April, May, October, November and December, and below it in the remaining months, the maximum occurring in May and the minimum in August. In the previous year the maximum was in January and the minimum in September.

Typhoid fever was, as usual, below the mean in the intensity of its prevalence in the first eight months of 1902, rising to a maximum in October. In 1902, as in 1901, the intensity of its prevalence in September and October was nearly equal.

The prevalence of measles was much above the mean in the first half of the year and below it in the last half, the maximum occurring in March and the minimum in September. The whole number of reported cases during the year was greater than those reported in 1901 by 7,851.

The figures relating to small-pox may be found in the general report at the beginning of this volume (page xv).

Certain Infectious Diseases. Seasonal Intensity of Prevalence.

Months.	Diphtheria.			Scarlet Fever.			Typhoid Fever.			Measles.		
	1902.		**1901**	**1902.**		**1901.**	**1902.**		**1901.**	**1902.**		**1901.**
	A	**B**	**B**	**A**	**B**	**B**	**A**	**B**	**B**	**A**	**B**	**B**
	Mean Daily Number of Cases reported in Each Month.	Decimal Ratio.	Decimal Ratio.	Mean Daily Number of Cases reported in Each Month.	Decimal Ratio.	Decimal Ratio.	Mean Daily Number of Cases reported in Each Month.	Decimal Ratio.	Decimal Ratio.	Mean Daily Number of Cases reported in Each Month.	Decimal Ratio.	Decimal Ratio.
January, .	25.4	13.2	17.9	12.4	9.8	16.8	4.9	6.6	8.9	56.5	12.0	6.0
February, .	23.7	12.3	13.5	13.9	11.0	12.7	5.2	7.0	4.2	82.8	17.5	6.1
March, .	19.8	10.3	11.8	11.5	9.1	13.2	4.1	5.5	4.5	94.0	19.9	9.0
April, .	18.1	9.4	9.2	12.9	10.2	11.1	3.7	5.0	5.3	80.6	17.1	13.4
May, . .	18.9	9.8	8.1	14.2	11.2	9.7	4.7	6.3	4.1	93.3	19.7	16.6
June, .	16.2	8.4	9.1	11.9	9.4	8.5	4.1	5.5	5.3	58.8	12.4	18.3
July, . .	11.6	6.0	5.4	8.3	6.6	6.7	4.4	5.9	4.4	22.4	4.7	9.5
August, .	12.0	6.2	5.9	7.9	6.3	6.5	6.8	9.1	14.5	7.7	1.6	2.4
September,	16.3	8.5	6.1	9.4	7.4	5.8	15.1	20.2	22.4	4.6	1.0	1.8
October, .	23.1	12.0	10.2	12.8	10.1	8.1	15.2	20.4	22.1	8.3	1.7	5.2
November,	25.0	13.0	13.6	18.6	14.7	9.6	11.5	15.4	13.0	22.1	4.7	14.8
December,	21.4	11.1	9.4	18.2	14.4	11.4	9.7	13.1	11.6	38.6	8.2	16.8
Mean, .	19.3	10.0	10.0	12.6	10.0	10.0	7.4	10.0	10.0	47.3	10.0	10.0

The following table presents the number of cases of infectious diseases reported to the Board from each city and town in 1902. The whole number of cases was greater by 6,924 than that of 1901, and the number of reporting cities and towns was 261 or five more than those of 1901.

Cases of Infectious Diseases reported to the State Board of Health from Two Hundred and Sixty-one Cities and Towns during 1902.

	Small-pox.	Scarlet Fever.	Diphtheria.	Typhoid Fever.	Measles.		Small-pox.	Scarlet Fever.	Diphtheria.	Typhoid Fever.	Measles.
Abington,	3	6	2	–	26	Canton,	1	4	3	1	18
Acton,	5	1	2	1	3	Carver,	–	–	1	–	–
Acushnet,	–	6	–	1	4	Charlton,	–	2	–	1	–
Adams,	–	4	8	41	–	Chatham,	1	–	–	–	–
Agawam,	–	–	2	–	–	Chelmsford,	–	3	28	4	53
Amesbury,	1	18	1	4	12	CHELSEA,	18	29	128	22	243
Amherst,	–	1	–	–	–	Chester,	–	1	–	–	–
Andover,	12	6	6	6	28	CHICOPEE,	7	57	126	10	58
Arlington,	7	4	6	5	97	Clinton,	4	8	13	17	119
Ashfield,	–	1	–	–	–	Cohasset,	–	20	2	3	5
Athol,	13	3	5	4	29	Colrain,	–	1	–	–	–
Attleborough,	3	29	5	3	25	Concord,	3	4	10	4	17
Auburn,	–	4	1	–	–	Cottage City,	1	–	–	–	–
Avon,	–	3	3	1	–	Dalton,	7	5	1	–	–
Ayer,	–	3	4	–	59	Dana,	–	–	–	–	1
Barnstable,	–	1	1	–	7	Danvers,	4	8	12	6	2
Barre,	1	–	–	–	11	Dartmouth,	–	2	2	–	–
Bedford,	1	3	3	–	5	Dedham,	–	35	12	1	55
Belchertown,	–	–	–	2	11	Deerfield,	–	7	–	–	57
Bellingham,	2	–	1	–	–	Dennis,	–	3	4	–	–
Belmont,	–	12	6	7	34	Dighton,	–	7	12	–	–
Berlin,	–	–	–	1	1	Douglas,	8	4	–	–	3
BEVERLY,	3	3	7	26	26	Dover,	3	–	–	–	–
Billerica,	–	10	9	–	60	Dracut,	–	–	18	–	9
Blackstone,	7	–	–	–	–	Dudley,	48	2	1	–	–
Bolton,	–	2	–	–	–	Dunstable,	–	–	–	1	4
BOSTON,	1,020	1,143	1,967	860	3,845	Duxbury,	–	–	1	1	177
Bourne,	–	3	–	–	–	E. Bridgewater,	–	–	2	2	–
Braintree,	4	24	17	4	35	Easthampton,	7	–	3	–	–
Brewster,	–	–	–	–	7	E. Longmeadow,	–	3	1	–	1
Bridgewater,	–	8	1	–	3	Easton,	–	4	27	1	1
BROCKTON,	19	34	72	35	43	Edgartown,	–	–	–	1	–
Brookfield,	–	4	–	11	–	Essex,	–	–	3	2	18
Brookline,	10	52	61	17	174	EVERETT,	51	31	62	26	425
CAMBRIDGE,	177	201	452	126	406	Fairhaven,	–	2	2	5	65

Cases of Infectious Diseases reported to the State Board of Health from Two Hundred and Sixty-one Cities and Towns during 1902 — Continued.

	Small-pox.	Scarlet Fever.	Diphtheria.	Typhoid Fever.	Measles.		Small-pox.	Scarlet Fever.	Diphtheria.	Typhoid Fever.	Measles.
FALL RIVER,	14	556	115	49	15	Hull,	-	1	1	-	7
Falmouth,	1	3	9	-	232	Huntington,	-	1	-	1	-
FITCHBURG,	10	24	45	38	334	Hyde Park,	7	4	55	7	196
Foxborough,	1	2	1	3	1	Ipswich,	2	5	10	10	6
Framingham,	3	-	30	7	45	Kingston,	-	1	-	-	-
Franklin,	17	3	4	5	2	Lancaster,	-	9	3	-	37
Freetown,	-	1	-	-	2	LAWRENCE,	19	82	84	100	712
Gardner,	24	5	2	4	-	Lee,	-	1	-	-	-
Georgetown,	-	4	-	-	5	Leicester,	-	4	-	-	-
Gill,	-	2	-	-	-	Lenox,	-	1	14	-	-
GLOUCESTER,	7	33	336	8	30	Leominster,	1	10	16	5	12
Grafton,	-	-	1	-	-	Lexington,	-	3	1	-	105
Great Barrington,	3	11	-	-	-	Lincoln,	-	2	-	-	1
Greenfield,	-	7	5	3	4	LOWELL,	56	108	651	87	802
Greenwich,	-	-	-	1	-	Ludlow,	-	-	4	3	-
Groton,	-	3	2	3	11	Lunenberg,	3	-	-	-	2
Groveland,	-	1	1	2	11	LYNN,	18	29	195	67	622
Hadley,	-	-	-	1	3	MALDEN,	39	68	93	63	583
Halifax,	-	-	-	-	5	Manchester,	-	-	1	1	31
Hamilton,	1	-	3	-	-	Mansfield,	-	4	2	2	-
Hampden,	-	-	-	-	22	Marblehead,	9	4	5	3	18
Hanson,	-	-	-	-	5	Marion,	-	-	-	1	-
Hardwick,	61	10	5	4	-	MARLBOROUGH,	11	27	170	6	11
Harvard,	-	-	-	2	-	Marshfield,	2	1	-	2	52
Hatfield,	-	2	-	-	20	Mattapoisett,	-	7	2	1	91
HAVERHILL,	2	26	76	66	1,339	Maynard,	4	-	2	2	1
Hingham,	1	5	1	-	-	Medfield,	-	-	14	2	11
Hinsdale,	-	-	5	-	-	MEDFORD,	10	20	38	17	204
Holbrook,	-	-	1	1	-	Medway,	-	2	1	2	8
Holden,	-	-	-	1	1	MELROSE,	6	18	29	6	59
Holliston,	1	3	11	1	38	Mendon,	2	-	-	-	-
HOLYOKE,	39	33	104	32	42	Merrimac,	-	-	8	-	-
Hopedale,	2	9	8	-	-	Methuen,	1	-	-	-	-
Hopkinton,	-	1	5	-	80	Middleborough,	-	13	14	5	99
Hudson,	-	14	6	7	6	Middleton,	-	1	-	-	-

Cases of Infectious Diseases reported to the State Board of Health from Two Hundred and Sixty-one Cities and Towns during 1902 — Continued.

	Small-pox.	Scarlet Fever.	Diphtheria.	Typhoid Fever.	Measles.		Small-pox.	Scarlet Fever.	Diphtheria.	Typhoid Fever.	Measles.
Milford, . .	-	10	7	14	53	Provincetown, .	2	-	3	-	-
Millbury, . .	2	6	5	5	35	QUINCY, . .	13	15	81	27	300
Millis, . . .	1	-	1	-	19	Randolph, . .	3	1	8	1	2
Milton, . .	3	3	41	11	160	Reading, . .	1	11	14	4	201
Monson, . .	-	3	4	3	15	Rehoboth, . .	-	1	-	-	-
Montague, . .	1	20	1	2	4	Revere, . .	12	27	45	-	-
Nahant, . .	-	-	-	1	-	Rockland, . .	-	2	-	11	49
Natick, . .	2	17	4	-	-	Rockport, . .	2	1	13	2	14
Needham, . .	-	1	-	1	26	Rowley, . .	-	8	-	2	2
NEW BEDFORD, .	19	136	94	161	67	Royalston, . .	3	-	4	-	2
Newbury, . .	4	-	1	-	-	Rutland, . .	2	-	-	-	-
NEWBURYPORT, .	9	16	28	27	41	SALEM, . .	37	30	84	42	413
New Salem, .	-	5	-	-	-	Salisbury, . .	1	-	-	-	-
NEWTON, . .	18	33	98	41	707	Sandisfield, . .	-	-	2	-	-
Norfolk, . .	-	-	-	-	1	Sandwich, . .	-	-	-	1	1
NORTH ADAMS, .	1	58	58	31	113	Saugus, . .	3	3	7	-	2
NORTHAMPTON, .	1	31	49	11	39	Scituate, . .	-	2	2	-	-
North Andover, .	-	3	4	7	91	Seekonk, . .	-	8	-	-	-
N. Attleborough,	1	12	2	1	3	Sharon, . .	2	-	2	2	3
Northborough, .	-	2	5	4	3	Sheffield, . .	1	-	-	-	-
Northbridge, .	43	4	-	-	20	Shelburne, . .	-	7	-	-	-
N. Brookfield, .	2	13	18	-	-	Sherborn, . .	-	-	6	-	4
Northfield, . .	-	3	6	2	35	Shirley, . .	2	2	1	-	8
North Reading, .	-	7	-	-	-	Somerset, . .	-	35	3	3	-
Norwell, . .	-	-	-	-	50	SOMERVILLE, .	68	78	232	22	243
Norwood, . .	-	4	11	8	15	Southampton, .	-	5	4	1	-
Oakham, . .	-	-	-	-	5	Southborough, .	-	-	1	4	-
Orange, . .	1	11	1	1	145	Southbridge, .	43	11	4	6	14
Oxford, . .	-	4	-	2	1	South Hadley, .	-	-	5	2	1
Palmer, . .	-	11	46	12	231	Spencer, . .	-	5	-	-	-
Peabody, . .	6	5	20	3	43	SPRINGFIELD, .	12	152	144	45	26
Pepperell, . .	-	9	3	1	9	Sterling, . .	-	2	1	-	1
PITTSFIELD, .	4	5	21	13	-	Stockbridge, .	-	7	-	2	15
Plymouth, . .	-	15	14	24	2	Stoneham, . .	2	7	9	-	1
Princeton, . .	-	-	2	-	1	Stoughton, . .	6	2	17	-	-

Cases of Infectious Diseases reported to the State Board of Health from Two Hundred and Sixty-one Cities and Towns during 1902 — Concluded.

	Small-pox.	Scarlet Fever.	Diphtheria.	Typhoid Fever.	Measles.		Small-pox.	Scarlet Fever.	Diphtheria.	Typhoid Fever.	Measles.
Stow, . . .	-	1	-	-	-	Westborough, .	-	2	1	2	2
Sturbridge, . .	17	7	-	-	-	West Boylston, .	-	-	-	-	3
Sudbury, . .	-	1	-	-	2	West Brookfield,	-	3	-	2	28
Sutton, . .	1	-	2	2	3	Westfield, . .	4	42	29	11	28
Swampscott, .	1	3	5	4	139	Westford, . .	-	-	3	6	4
Swansea, . .	2	-	1	-	-	Westhampton, .	-	-	-	-	1
TAUNTON, . .	18	38	22	-	1	Westminster, .	-	2	-	-	1
Templeton, . .	-	1	15	-	-	West Newbury, .	-	-	5	-	-
Tewksbury, .	5	1	2	2	-	Weston, . .	1	3	2	-	8
Tisbury, . .	-	5	1	-	4	Westport, . .	2	-	2	7	3
Tolland, . .	-	1	-	-	-	West Springfield,	1	11	3	-	-
Townsend, . .	-	-	3	1	11	Weymouth, .	9	30	14	-	12
Tyringham, .	1	-	-	-	-	Whitman, . .	1	2	2	-	63
Upton, . . .	-	-	-	2	5	Wilbraham, .	-	2	1	-	-
Uxbridge, . .	-	5	3	3	51	Williamsburg, .	-	-	1	-	2
Wakefield, . .	-	4	14	27	235	Williamstown, .	-	7	7	1	20
Walpole, . .	-	3	5	9	2	Wilmington, .	-	-	5	2	1
WALTHAM, . .	4	38	60	32	199	Winchendon, .	-	2	3	19	7
Ware, . . .	13	9	1	-	-	Winchester, .	6	7	19	6	15
Wareham, . .	1	6	3	3	21	Windsor, . .	1	3	-	-	-
Warren, . .	-	13	5	1	119	Winthrop, . .	4	13	28	4	150
Watertown, .	11	16	30	6	14	WOBURN, . .	1	14	13	11	9
Wayland, . .	17	2	-	-	-	WORCESTER, .	6	375	148	90	574
Webster, . .	25	53	14	3	42	Worthington, .	-	-	14	-	-
Wellesley, . .	1	4	7	4	24	Wrentham, . .	-	-	2	4	-
Wenham, . .	-	-	-	-	15	Total, . .	2,314	4,613	7,036	2,721	17,249

The following list comprises the cities and towns which failed to report (under the provisions of the statute) to the State Board of Health.

It is but just to state that in many of the towns named in group IV. and in some of those in group III. it is quite probable that no cases of infectious diseases occurred during the year.

LIST OF CITIES AND TOWNS FROM WHICH NO REPORTS WERE RECEIVED.

I. Cities.

None.

II. Towns having a Population of More than 5,000.

None.

III. Towns having a Population of More than 1,000 but Less than 5,000 in Each.

Ashburnham,
Ashland,
Buckland,
Cheshire,
Conway,
Hanover,
Hubbardston,
Littleton,
New Marlborough,
Norton,
Orleans,
Raynham,
Shrewsbury,
West Bridgewater,
West Stockbridge,
Yarmouth. — 16.

IV. Towns having Less than 1,000 Inhabitants.

Alford,
Ashby,
Becket,
Berkley,
Bernardston,
Blandford,
Boxboro,
Boxford,
Burlington,
Carlisle,
Chesterfield,
Chilmark,
Clarksburg,
Cummington,
Eastham,
Egremont,
Erving,
Florida,
Gay Head,
Goshen,
Gosnold,
Granby,
Hancock,
Hawley,
Heath,
Holland,
Lakeville,
Lanesborough,
Leverett,
Leyden,
Longmeadow,
Lynnfield,
Mashpee,
Middlefield,
Monroe,
Monterey,
Montgomery,
Mt. Washington,
New Ashford,
New Braintree,
Otis,
Paxton,
Pelham,
Peru,
Petersham,
Phillipston,
Plainfield,
Plympton,
Prescott,
Richmond,
Rochester,
Rowe,
Russell,
Savoy,
Shutesbury,
Sunderland,
Truro,
Tyngsborough,
Wales,
Warwick,
Washington,
Wendell,
West Tisbury,
Whately. — 64.

The following towns sent notices to the Board that no infectious diseases had been reported within their limits during the year 1902 : —

Boylston,
Brimfield,
Charlemont,
Enfield,
Granville,
Harwich,
Nantucket,
Pembroke,
Southwick,
Topsfield,
Wellfleet,
Westwood. — 12.

A supply of postal cards for the purpose of reporting infectious diseases to the State Board of Health, as required by statute, will be forwarded to any local board of health on application to the Secretary of the State Board, Room 141, State House, Boston.

IV.

OFFICIAL RETURNS OF DEATHS IN CITIES AND LARGE TOWNS (REVISED LAWS, CHAPTER 75, SECTION 12).

The following summary comprises the results obtained from the tabulation of the returns required by chapter 75, section 12, of the Revised Laws, whereby the board of health of each city and populous town is directed to send to the State Board of Health an annual statement of the deaths in such city or town upon a blank form furnished by the State Board.

All of the towns except Montague have made the returns required by law, and in addition the towns of Reading and Grafton have voluntarily contributed returns in 1900, 1901 and 1902, although not required to do so by law. Four other towns which did not contribute to the report of 1901 have made returns in 1902, so that the list now embraces 94 cities and towns, including all of the 33 cities and all of the towns having a population of more than 5,000 in each, except Montague. The estimated population of these cities and towns in 1902 was 2,497,015, or about 85 per cent. of the estimated population of the State in that year.

The whole number of registered deaths in these towns in 1902 was 40,469, and the death-rate, as calculated for that year from the census population of the reporting cities and towns, was 16.21 per 1,000 of the living population, that of the previous year having been 16.86 per 1,000 and that of 1900, 18.26 per 1,000. This was the lowest death-rate observed in this reporting population during the period of nine years since the enactment of the law requiring these returns. The mean annual death-rate of the State for the fifty years ended Dec. 31, 1900, was 19.22 per 1,000.

Sexes. — The number of deaths of males was 20,418, or 50.4 per cent. of the whole number of those whose sex was known; and the deaths of females were 20,042 or 49.6 per cent. There were 9 in which the sex was not stated in the returns.

Ages. — The deaths by four groups of ages were as follows: —

AGES.	Deaths. 1902.	PERCENTAGES OF ALL DEATHS.		AGES.	Deaths. 1902.	PERCENTAGES OF ALL DEATHS.	
		1902.	**1901.**			**1902.**	**1901.**
Under 1 year,	8,778	21.72	21.64	20 to 50 years,	10,114	25.02	25.25
1 to 20 years,	6,340	15.68	15.59	50 and over,	15,193	37.58	37.52
						100.00	100.00

The deaths of infants under one year old were 8,778, or 21.7 per cent. of the total mortality, as compared with 21.6 per cent. in the previous year; and those of children under five years old were 12,630, or 31.2 per cent. of the total mortality, as compared with 30.1 per cent. in 1901.

All of the percentages in the foregoing table were estimated upon the number of deaths of those whose ages were specified in the returns. The total number of deaths in which the age was not specified was 44.

The infant mortality for the five years 1898–1902 respectively constituted 24.8, 22.8, 23, 21.6 and 21.7 per cent. of the total mortality, that of the two years 1901 and 1902 being the lowest infant mortality of the period.

Still-births. — The number of still-births was 2,732, and when compared with the total mortality (still-births included) this was 6.3 of the total deaths and still-births combined.

Months and Quarters. — The number of deaths in each quarter of the year is shown in the following table: —

	Deaths. 1902.	Percentages.	
		1902.	**1901.**
First quarter,	9,959	24.61	27.39
Second quarter,	9,673	23.90	23.10
Third quarter,	10,611	26.22	25.80
Fourth quarter,	10,224	25.27	23.71
Total,	40,467	100.00	100.00

These percentages differ but little from the mean of several years, which usually shows the highest mortality in the third quarter of the year. In 1901 and 1899 the highest mortality was in the first quarter.

During the forty-year period (1856–95) the mortality was generally above the mean in the third quarters of the years and below it in the other three quarters.

The intensity of the seasonal death-rate is more accurately shown in the following table, the method employed being explained on page 541 in Section III. of these summaries, relating to disease notification. By this method the errors which are due to differences in the length of the months are eliminated.

	Deaths in Each Month.	Mean Daily Deaths per Month. 1902.	Centesimal Ratio.			Deaths in Each Month	Mean Daily Deaths per Month. 1902.	Centesimal Ratio.	
			1902.	**1901.**				**1902.**	**1901.**
January,	3,271	105.5	95.1	108.8	August,	3,637	117.3	105.8	107.1
February,	3,300	117.9	106.3	113.2	September,	3,434	114.5	103.2	105.6
March,	3,388	109.3	98.5	111.4	October,	3,380	109.0	98.3	92.4
April,	3,318	110.6	99.7	102.3	November,	3,224	107.5	96.9	94.0
May,	3,375	108.9	98.2	89.1	December,	3,620	116.8	105.3	95.9
June,	2,980	99.3	89.5	86.7					
July,	3,540	114.2	103.0	94.5	Annual mean,	-	110.9	100.0	100.0

The figures in the foregoing table indicate a departure in excess of the mean death-rate in February, July, August, September and December, while that of the remaining months was low.

The mean maximum departure from the death-rate for each month for the period of twenty years, 1856–75, was 32.9 per cent. in August, and the twenty-year period 1876–95 it was 20 per cent. in August, while that of February, 1902, was 6.3 per cent. and that of August, 1902, was 5.8 per cent.

In the two years having the highest death-rates in Massachusetts in the past half-century or more (1849 and 1872) the maximum departures from the yearly means were, respectively, 83.4 per cent. in August, 1849, and 40 per cent. in August, 1872. That of January, 1890, the month in which the epidemic of influenza was at its maximum, was 43.4 per cent. above the mean.

In the early history of the State, when the population was more uniformly distributed than it is at present, and was not so densely settled in cities and large towns, it was a common custom to publish yearly statistics grouped according to the different county limits; but at the present day such methods of classification have no significance, no one cares for them and they are absolutely without value. The birth-rate, the marriage-rate or the death-rate of a county are questions of no importance whatever, since they have neither significance nor any practical value so far as the more densely settled New England States are concerned. On the other hand municipal statistics are increasing in importance, as the aggregation of the population in cities and large towns increases.

In Table II. of this report of deaths decided differences in the death-rates appear upon examination, the figures varying from a minimum of 6.03 per 1,000 in Winthrop to a maximum of 21.85 per 1,000 in Blackstone.

The following cities and towns had death-rates above 19 per 1,000: Blackstone, 21.85; Palmer, 20.78; New Bedford, 20.53; Fall River, 19.87; Lowell, 19.43; Chicopee, 19.42, and Newburyport, 19.34.

The following cities and towns had death-rates less than 12 per 1,000: North Attleborough, 11.83; Attleborough, 11.68; Spencer, 11.53; Orange, 11.46; Brockton, 10.99; Northampton, 10.89; Medford, 10.79; Winchendon, 10 56; Whitman, 10.29; Westborough, 9.70; Concord, 9.41; Norwood, 9.41; Williamstown, 8.69; Winchester, 7.80; Wellesley, 7.39; Winthrop, 6.03.

The death-rates of the large cities of the State were as follows: Boston, 18.66 per 1,000; Worcester, 13.42; Fall River, 19.87; Lowell, 19.43; Cambridge, 15.09; Lynn, 14.18; Lawrence, 17.29; New Bedford, 20.53; Springfield, 15.33; Somerville, 13.51; Holyoke, 15.69; Brockton, 10.99; Haverhill, 14.38; Salem, 17.91; Chelsea, 18.18; Malden, 13.85: Newton, 12.16; Fitchburg, 13.38; Taunton, 14.04; Gloucester, 15.66. Each of the foregoing cities had a population of more than 25,000 by the census of 1900.

The combined death-rate of the three shoe manufacturing cities, Brockton, Haverhill and Lynn, was 13.3; that of the four textile manufacturing cities, Fall River, New Bedford, Lowell and Lawrence, was 19.4.

In several of the towns which had very low death-rates special conditions prevailed, which would, partially at least, account for such low death-rates.

Accurate comparisons cannot be made of the death-rates of different cities and towns in the absence of knowledge as to the sex and age constitution of their inhabitants. Another item which affects the death-rate unfavorably is the presence of large public and private institutions, in which non-residents are treated. For example, in the census year 1900 there were more than 400 deaths of non-residents in the institutions of Boston, which contributed to raise the death-rate of the city. (For further information as to methods of correcting the death-rates of cities, see general report in the early part of this volume under the title of "Death-rates of Cities.")

Causes of Death.

In Table III., the mortality of the cities and towns embraced in this summary is presented in absolute figures, classified according to the principal causes of death. The same figures are again presented in relative terms in Table IV., for the whole group of cities and towns combined. Two sets of figures are given in Table IV., in one of which the mortality from each principal cause of death is compared with the estimated population of the group for 1902, as well as for each of the last five years, and in the other with the total mortality of the group of cities and towns.

By this it appears that the general death-rate from all causes, as shown in the lower line at the left of the table, 162.07 per 10,000 living, or, as usually stated, 16.21 per 1,000, was lower than that of either of the preceding years, and since the population comprised in these returns constitutes over 85 per cent. of that of the whole State, there are indications that the death-rate of the State was less than that of any year in the past century.

As was stated in last year's report, the decline in the general death-rate is chiefly due to a decrease in the relative number of deaths from infectious diseases, and especially from those which are usually considered as preventable.

The death-rates from each of the following causes was less than that of 1901: consumption, scarlet fever, diphtheria, typhoid fever, cerebro-spinal meningitis, erysipelas, puerperal fever, influenza, malarial fever, cholera infantum, dysentery, pneumonia, heart diseases and kidney diseases. Those of consumption, typhoid fever, cerebro-spinal meningitis, influenza, malarial fever, cholera infantum and dysentery were also less than the death-rates from the same causes in any of the last five years.

The following table, first published in the report of 1899, presents the combined death-rate from eight of the principal infectious diseases, and also shows that this combined death-rate in 1902 was less than that of any of the years embraced in this series of reports.

The diseases referred to are consumption, measles, scarlet fever, diphtheria, whooping-cough, typhoid fever, puerperal fever and cholera infantum.

The combined death-rate per 10,000 of the population from these eight causes for the eight years (1895–1902) in the cities and towns included in this report (about five-sixths of the total population of the State) was as follows: —

Combined Death-rate from Eight Principal Infectious Diseases.

YEAR.	Combined Death-rate per 10,000.	YEAR.	Combined Death-rate per 10,000.
1895, ...	46.4	1899, ...	35.2
1896, ...	46.8	1900, ...	40.7
1897, ...	39.7	1901, ...	33.5
1898, ...	36.3	1902, ...	30.9

The seasonal table which appeared in the earlier reports, presenting the deaths by months for each city and town and for the whole State, is omitted in the present report, since the details presented in this table are not of essential value. Its chief value consisted in the column of total figures for the State, which is retained essentially in the table on page 549.

The table of percentages of total mortality shown in Table IV. acts in a measure as a check or control in case of erroneous estimates of population; and, while such errors are not to be found in the figures of a census year, it seems best, as a matter of uniformity, to publish the table in the same form as in previous intercensal years.

The changes in the death-rate from consumption, typhoid fever and puerperal fever (see child-birth in report of 1896, page 804) were quite fully treated in the report of 1896. To these may be added the later comments on the changes in the death-rate from diphtheria, which appear in the figures of the past eight years.

The following preventable causes of death, consumption, measles, scarlet fever, diphtheria, whooping-cough, typhoid fever, puerperal fever and cholera infantum, together constituted 27.2 per cent. of the total mortality in 1894, but had fallen off to 24.2, 24.2, 21.9, 21.1, 20.4, 22.3, 19.9 and 19.0 in the eight succeeding years; while the principal acute lung diseases, diseases of the heart, brain, kidneys, cancer, suicide and accident had increased from 35.7 per cent. of the total mortality to 36.9, 36.9, 38.5, 39.2, 40.2, 38.6, 40.1 and 42.7 per cent. in the same years.

These all combined constituted the greater part of the total mortality in each of the nine years 1894–1902, and of the diseases specified in the table entitled the "Balance of Mortality," in the annual report of 1896, page 812.

TABLE I.

Population of Cities and Large Towns estimated for 1902.

REPORTING CITIES AND TOWNS.	Estimated Population for **1902.**	REPORTING CITIES AND TOWNS.	Estimated Population for **1902.**
Adams,	12,813	Milford,	12,516
Amesbury,	9,473	Milton,	7,002
Amherst,	5,126	Natick,	9,758
Andover,	7,081	NEW BEDFORD,	65,574
Arlington,	9,439	NEWBURYPORT,	14,478
Athol,	7,061	NEWTON,	36,336
Attleborough,	12,847	NORTH ADAMS,	26,583
BEVERLY,	14,814	NORTHAMPTON,	19,460
Blackstone,	5,721	North Attleborough,	7,523
BOSTON,	588,730	Northbridge,	7,736
Braintree,	6,249	Norwood,	5,842
Bridgewater,	6,254	Orange,	5,584
BROCKTON,	43,208	Palmer,	8,179
Brookline,	21,679	Peabody,	11,956
CAMBRIDGE,	96,334	PITTSFIELD,	22,311
CHELSEA,	35,264	Plymouth,	10,336
CHICOPEE,	20,390	QUINCY,	25,307
Clinton,	14,646	Reading,	5,069
Concord,	5,842	Revere,	11,894
Danvers,	8,686	Rockland,	5,327
Dedham,	7,555	SALEM,	36,567
Easthampton,	5,929	Saugus,	5,318
EVERETT,	27,114	SOMERVILLE,	65,882
FALL RIVER,	111,872	Southbridge,	10,838
FITCHBURG,	33,848	Spencer,	7,633
Framingham,	12,109	SPRINGFIELD,	66,854
Franklin,	5,017	Stoneham,	6,197
Gardner,	11,544	Stoughton,	5,510
GLOUCESTER,	26,121	TAUNTON,	32,759
Grafton,	4,869	Wakefield,	9,684
Great Barrington,	6,278	WALTHAM,	24,612
Greenfield,	8,605	Ware,	8,507
HAVERHILL,	40,392	Watertown,	10,600
Hingham,	5,155	Webster,	9,206
HOLYOKE,	48,065	Wellesley,	5,410
Hudson,	5,512	Westborough,	5,466
Hyde Park,	13,858	Westfield,	13,038
LAWRENCE,	67,275	West Springfield,	7,497
Leominster,	13,953	Weymouth,	11,337
LOWELL,	99,574	Whitman,	6,319
LYNN,	71,144	Williamstown,	5,063
MALDEN,	35,390	Winchendon,	5,205
Marblehead,	7,582	Winchester,	7,688
MARLBOROUGH,	13,609	Winthrop,	6,804
MEDFORD,	20,014	WOBURN,	14,285
MELROSE,	13,384	WORCESTER,	127,337
Methuen,	8,240		
Middleborough,	6,963	Total,	2,497,015

The death-rate of Amesbury, Athol, Blackstone, Franklin, Gloucester, Grafton, Marblehead, Marlborough, Newburyport, Rockland and Stoneham was based on the population of 1900, these towns having slightly decreased in population in the five years which elapsed between the census of 1895 and 1900.

Table II.

Total Deaths, Deaths by Sexes and Age Periods and Still-births in Cities and Towns having over 5,000 Inhabitants in Each with General Death-rates estimated for 1902.

	Total Deaths.	Males.	Females.	Sex Unknown.	Still-births.	Deaths under 1.	1-2.	2-3.	3-4.	4-5.	5-10.	10-15.	15-20.	20-30.	30-40.	40-50.	50-60.	60-70.	70-80.	Over 80.	Age Unknown.	Rate per 1,000.
Adams,	209	102	107	-	12	77	13	4	6	2	6	3	5	10	11	12	18	10	16	9	7	16.31
Amesbury,	166	82	84	-	13	24	4	3	1	-	11	4	3	8	13	20	17	22	18	18	-	17.52
Amherst,	70	32	38	-	2	5	1	-	-	1	-	-	2	6	2	1	2	14	18	16	2	13.66
Andover,	94	49	45	-	4	11	3	2	-	-	1	-	1	7	2	9	12	22	13	10	1	13.27
Arlington,	133	58	75	-	7	10	5	1	4	2	2	4	1	15	11	14	11	19	16	13	5	14.09
Athol,	125	73	52	-	5	13	6	-	1	-	1	1	2	11	9	9	11	15	24	22	-	17.70
Attleborough,	150	65	85	-	9	32	9	2	1	1	5	4	3	18	12	12	13	9	16	13	-	11.68
BEVERLY,	197	102	95	-	16	20	3	5	-	-	3	4	7	12	18	14	21	27	36	27	-	13.30
Blackstone,	125	59	66	-	7	25	9	2	1	3	6	1	3	9	16	11	5	10	15	9	-	21.85
BOSTON,	10,983	5,663	5,320	-	623	2,257	606	260	129	115	249	149	221	1,024	1,190	1,089	1,115	1,213	882	484	-	18.66
Braintree,	79	40	39	-	9	7	1	2	-	-	2	2	3	4	10	4	6	11	13	14	-	12.64
Bridgewater,	78	40	38	-	-	12	3	-	2	1	1	2	1	5	6	6	4	9	15	11	-	12.47
BROCKTON,	475	211	264	-	48	68	12	13	5	3	14	4	11	54	48	45	51	63	50	34	-	10.99
Brookline,	301	130	171	-	18	38	9	7	3	1	5	2	6	26	23	33	40	36	41	31	-	13.88
CAMBRIDGE,	1,454	718	736	-	117	314	83	24	20	19	37	17	44	138	113	128	145	171	130	71	-	15.09
CHELSEA,	641	364	277	-	31	135	33	17	8	5	15	7	10	47	42	31	72	101	82	36	-	18.18
CHICOPEE,	396	199	197	-	13	144	38	16	6	8	19	3	4	16	25	17	28	34	18	20	-	19.42
Clinton,	220	109	111	-	24	50	5	-	6	1	3	3	6	17	18	20	21	29	26	14	1	15.02
Concord,	55	21	34	-	3	11	2	-	1	-	1	1	3	4	4	4	7	6	7	4	-	9.41
Danvers,	108	60	48	-	-	14	2	1	1	-	-	-	5	4	2	12	13	19	22	13	-	12.43
Dedham,	124	69	55	-	8	12	5	3	1	-	3	2	4	8	9	11	11	24	23	8	-	16.41
Easthampton,	87	34	53	-	3	24	7	3	2	-	1	1	4	5	3	4	6	8	9	10	-	14.67

EVERETT,	380	190	190	-	25	104	20	3	3	2	14	5	7	38	30	25	30	44	35	20	-	14.01
FALL RIVER,	2,223	1,085	1,138	-	266	817	-*	-*	-*	-*	87	-*	-*	155	154	129	181	156	78	38	-	19.87
FITCHBURG,	453	235	218	-	31	136	27	14	3	4	9	3	12	37	31	26	42	47	33	29	-	13.38
Framingham,	158	84	74	-	3	18	1	3	3	1	3	-	2	9	15	22	16	22	23	19	1	13.05
Franklin,	72	38	31	3	2	13	3	-	-	-	1	-	3	4	1	1	10	19	9	8	-	14.35
Gardner,	164	93	69	2	13	27	10	5	6	4	3	3	5	10	14	21	13	17	17	9	-	14.20
GLOUCESTER,	409	222	187	-	27	79	25	14	9	7	17	14	13	37	36	18	45	42	33	19	1	15.66
Grafton,	59	40	19	-	8	11	4	-	-	1	-	1	1	5	5	3	6	7	12	3	-	12.12
Great Barrington,	82	42	40	-	4	7	-	3	1	-	2	1	-	4	3	11	10	12	21	7	-	13.06
Greenfield,	106	58	48	-	3	17	1	3	2	2	2	-	1	10	5	8	8	15	22	9	1	12.34
HAVERHILL,	581	307	274	-	51	102	18	14	7	2	16	11	8	48	44	54	76	67	71	42	1	14.38
Hingham,	92	41	50	1	5	10	2	1	1	1	1	-	2	2	5	4	11	19	15	17	1	17.85
HOLYOKE,	754	365	389	-	77	241	39	17	10	8	23	4	21	60	72	49	62	72	51	25	-	15.69
Hudson,	92	50	42	-	8	15	3	-	1	-	2	-	2	5	4	9	18	11	14	8	-	16.69
Hyde Park,	194	97	97	-	14	44	8	2	3	1	3	5	2	25	10	18	20	17	26	8	2	14.00
LAWRENCE,	1,163	573	590	-	91	348	86	34	14	15	19	14	23	73	74	97	124	107	93	32	10	17.29
Leominster,	171	95	76	-	13	25	2	2	2	-	5	1	5	14	9	11	26	25	28	16	-	12.26
LOWELL,	1,935	971	964	-	142	519	101	47	47	22	66	27	41	114	165	170	174	213	153	76	-	19.43
LYNN,	1,009	484	525	-	71	182	48	17	9	10	33	10	22	92	73	92	109	132	111	69	-	14.18
MALDEN,	490	228	262	-	30	97	20	13	6	3	11	9	6	35	43	43	57	62	51	34	-	13.85
Marblehead,	117	57	59	1	2	9	3	2	3	1	-	1	3	6	3	8	15	19	32	12	-	15.43
MARLBOROUGH,	196	107	89	-	8	38	8	7	4	2	13	5	4	7	15	11	19	23	24	15	1	14.40
MEDFORD,	216	99	117	-	15	40	18	3	-	1	2	1	4	11	17	21	20	21	33	24	-	10.79
MELROSE,	199	92	107	-	10	21	6	5	1	1	5	-	10	13	21	19	18	21	34	24	-	14.87
Methuen,	137	67	69	1	8	25	9	4	-	2	1	5	-	10	12	18	8	13	21	8	1	16.63
Middleborough,	91	42	49	-	5	10	3	-	-	1	3	-	3	1	6	6	6	18	13	19	2	13.07
Milford,	192	88	104	-	-	36	11	5	5	3	2	2	2	8	19	16	17	25	23	18	-	15.34
Milton,	93	42	51	-	9	13	1	1	-	2	6	1	3	10	8	9	11	11	9	8	-	13.28
Natick,	153	69	84	-	8	21	5	1	3	1	-	3	5	13	13	10	11	27	25	15	-	15.68
NEW BEDFORD,	1,346	662	684	-	106	424	77	36	31	16	47	16	30	104	83	82	108	113	97	82	-	20.53
NEWBURYPORT,	280	144	136	-	25	44	14	2	3	2	5	4	5	25	18	21	25	42	41	29	-	19.34

* 337 deaths from one to five years; 91 from ten to twenty years.

TABLE II — *Concluded.*

	Total Deaths.	Males.	Females.	Sex Unknown.	Still-births.	Deaths under 1.	1-2.	2-3.	3-4.	4-5.	5-10.	10-15.	15-20.	20-30.	30-40.	40-50.	50-60.	60-70.	70-80.	Over 80.	Age Unknown.	Rate per 1,000.
NEWTON, ...	442	211	231	-	25	85	13	12	4	2	8	3	12	26	33	29	45	55	77	38	-	12.16
NORTH ADAMS, . . .	352	195	157	-	37	78	23	11	7	4	9	5	14	36	20	30	29	39	27	19	1	13.24
NORTHAMPTON,* . . .	258	137	121	-	11	43	9	2	-	-	5	5	4	14	18	18	33	36	41	30	-	10.89
North Attleborough, . .	89	49	40	-	7	19	1	3	1	-	6	3	1	5	7	6	6	9	13	9	-	11.83
Northbridge, . . .	96	54	42	-	4	32	7	3	-	3	1	-	1	8	2	2	8	8	9	12	-	12.41
Norwood, ...	55	25	30	-	10	10	4	-	-	-	3	6	3	5	1	2	2	1	14	4	-	9.41
Orange, ...	64	27	37	-	11	12	3	1	-	1	3	1	2	1	3	6	6	8	9	8	-	11.46
Palmer, ...	170	87	83	-	6	59	15	9	1	4	7	3	3	13	5	7	6	14	12	12	-	20.78
Peabody, ...	169	76	93	-	15	26	4	1	-	1	5	2	6	19	12	15	27	23	19	9	-	14.14
PITTSFIELD, ...	417	230	187	-	18	42	13	2	4	-	11	6	12	31	43	49	54	53	65	32	-	18.69
Plymouth, ...	171	89	82	-	4	27	3	1	-	-	7	2	3	11	9	12	16	28	33	19	-	16.54
QUINCY, ...	399	219	180	-	26	89	19	9	4	4	12	5	12	35	33	28	35	44	41	29	-	15.77
Reading, ...	67	34	32	1	4	3	2	2	-	1	3	3	2	4	1	9	10	12	10	5	-	13.22
Revere, ...	143	80	63	-	10	26	12	-	2	1	4	2	9	8	12	17	9	16	18	7	-	12.02
Rockland, ...	77	44	33	-	5	8	2	2	1	1	-	1	3	4	6	6	10	8	14	11	-	14.45
SALEM, ...	655	309	346	-	45	131	31	17	6	6	21	6	13	46	50	48	61	74	93	51	1	17.91
Saugus, ...	81	46	35	-	1	17	3	-	2	1	1	-	4	3	7	7	7	10	11	8	-	15.23
SOMERVILLE, ...	890	450	440	-	67	183	25	18	11	13	10	14	18	59	72	74	86	127	121	59	-	13.51
Southbridge, ...	158	80	78	-	16	42	10	3	1	2	2	3	5	8	9	13	8	16	22	14	-	14.58
Spencer, ...	88	48	40	-	6	5	4	-	1	1	3	2	3	10	8	1	14	13	14	9	-	11.53
SPRINGFIELD, ...	1,025	510	515	-	49	197	33	20	13	7	28	9	22	98	84	76	116	133	106	83	-	15.33
Stoneham, ...	115	51	64	-	3	11	3	1	-	-	4	3	2	5	4	8	12	24	18	20	-	18.56
Stoughton, ...	85	34	51	-	2	10	3	1	3	-	2	1	2	8	8	5	7	9	16	10	-	15.43
TAUNTON,†	567	302	265	-	26	93	13	5	5	3	13	6	11	47	58	42	63	81	72	55	-	14.04
Wakefield, ...	147	74	73	-	3	16	4	1	1	1	2	1	2	15	11	6	20	22	28	17	-	15.17

WALTHAM, ...	326	161	165	-	16	42	7	3	5	5	10	12	8	31	24	32	31	47	40	28	1	13.25
Ware, ...	150	64	86	-	9	55	3	1	2	-	1	5	4	8	11	8	12	15	16	9	-	17.63
Watertown, ...	138	68	70	-	17	32	4	2	1	1	4	4	-	16	6	7	14	13	19	14	1	13.02
Webster, ...	164	84	80	-	17	40	15	13	8	4	15	4	2	10	9	6	13	2	12	10	1	17.81
Wellesley, ...	40	13	27	-	4	6	3	1	1	1	1	1	-	3	-	3	6	6	1	7	-	7.39
Westborough,‡ . . .	139	70	69	-	1	2	1	-	1	-	-	1	4	10	7	20	24	28	22	19	-	9.70
Westfield, ...	215	112	103	-	12	36	7	4	6	2	8	5	3	20	16	11	19	29	36	13	-	16.49
West Springfield, . .	98	53	45	-	2	23	1	3	3	3	3	-	7	4	6	6	8	14	10	7	-	13.07
Weymouth, ...	174	87	87	-	14	25	2	3	3	3	1	1	2	8	13	15	21	26	34	17	-	15.35
Whitman, ...	65	24	41	-	6	6	1	2	-	1	3	-	2	6	5	6	8	14	8	3	-	10.29
Williamstown, . . .	44	24	20	-	5	12	-	-	-	2	-	-	1	4	1	4	3	3	10	3	1	8.69
Winchendon, . . .	55	27	28	-	8	16	2	2	-	2	1	2	1	1	1	6	3	7	8	3	-	10.56
Winchester, . . .	60	32	28	-	2	12	3	-	-	-	4	5	-	5	5	3	6	8	5	4	-	7.80
Winthrop, ...	41	18	23	-	2	1	-	1	2	1	-	-	-	4	-	8	3	5	9	6	1	6.03
WOBURN, ...	228	116	112	-	11	53	7	5	-	-	2	-	8	18	19	17	35	16	24	24	-	15.96
WORCESTER,§ . . .	1,875	957	918	-	143	357	73	34	24	18	31	19	41	188	191	195	182	221	186	115	-	13.42
Totals, ...	40,469	20,418	20,042	9	2,732	8,778	1,820	821	498	376	1,040	511	846	3,288	3,425	3,401	4,003	4,628	4,081	2,481	44	16.21

* Includes 46 deaths at Northampton Insane Asylum.
† Includes 107 deaths at Taunton Insane Asylum.
‡ Includes 86 deaths at Westborough Insane Asylum.
§ Includes 166 deaths at Worcester Insane Asylum.

These deaths are not included in estimating the death-rate of the town.

TABLE III.

Deaths from Specified Causes in Cities and Towns having more than 5,000 Inhabitants in Each.

	Consumption.	Small-pox.	Measles.	Scarlet-Fever.	Diphtheria and Croup.	Whooping-cough.	Typhoid Fever.	Cerebro-spinal Meningitis.	Erysipelas.	Puerperal Fever.	Influenza.	Malarial Fever.	Cholera Infantum.	Dysentery.	Diarrhœa and Cholera Morbus.	Pneumonia.	Bronchitis.	Diseases of the Heart.	Diseases of the Brain and Spinal Cord.	Diseases of the Kidneys.	Cancer.	Suicide.	Accident.	Unknown or Ill-defined Causes.	All Other Causes.
Adams, . . .	16	-	-	2	2	3	5	3	-	-	-	-	16	1	8	18	3	13	4	6	7	3	6	6	87
Amesbury, . .	16	-	1	2	3	1	2	7	-	-	6	-	4	3	2	34	1	24	7	11	8	-	5	-	29
Amherst, . . .	6	-	-	-	-	-	1	-	-	-	-	-	-	-	-	5	-	15	10	5	5	-	2	-	21
Andover, . . .	7	3	1	-	-	-	1	-	-	1	-	-	-	-	1	12	3	15	5	1	4	2	1	-	36
Arlington, . . .	19	1	-	-	2	2	1	5	-	-	-	-	11	-	-	13	1	18	-	8	13	2	11	9	16
Athol, . . .	12	2	-	-	1	-	1	4	-	-	-	3	1	1	1	16	1	14	21	5	2	4	3	-	33
Attleborough, . .	18	-	1	-	3	-	1	8	-	-	-	-	7	3	-	16	2	10	4	9	11	2	7	-	48
BEVERLY, . . .	25	-	1	-	1	-	3	-	-	-	-	-	2	-	1	17	6	34	14	19	15	1	8	11	39
Blackstone, . .	12	1	-	-	2	-	2	3	-	-	-	-	10	6	1	9	1	12	5	4	2	-	6	-	49
BOSTON, . . .	1,211	190	66	87	225	62	139	62	65	32	20	8	186	36	458	1,115	339	1,033	850	556	482	83	480	130	3,037
Braintree, . . .	8	-	-	-	3	-	1	-	-	-	1	-	-	1	-	8	3	9	14	4	5	1	1	-	20
Bridgewater, . .	10	-	-	-	-	4	-	-	1	-	2	-	1	-	2	5	1	12	4	2	3	-	4	13	14
BROCKTON, . .	76	-	1	2	7	2	6	15	-	1	1	2	5	2	2	31	7	37	27	2	31	3	9	-	206
Brookline, . .	26	1	-	4	1	1	2	1	-	-	1	-	2	-	-	32	11	41	20	13	23	1	9	-	111
CAMBRIDGE, . .	184	32	4	9	35	9	17	4	5	4	2	-	51	6	39	164	39	138	164	55	79	12	52	92	256
CHELSEA, . . .	48	-	9	2	11	8	10	2	1	1	-	-	15	2	7	53	10	66	15	29	32	4	14	-	302
CHICOPEE, . .	17	-	2	14	20	1	2	-	-	1	1	2	30	-	6	28	13	23	55	20	10	1	11	2	137
Clinton, . . .	19	-	2	-	3	1	3	7	-	-	-	2	6	2	2	23	7	23	13	9	6	1	9	-	82
Concord, . . .	8	-	-	-	-	-	1	4	-	-	1	-	5	-	-	3	1	7	2	4	-	1	1	-	17
Danvers, . . .	15	-	-	-	-	-	1	8	-	-	-	1	-	-	-	9	3	15	3	4	5	1	1	-	42
Dedham, . . .	11	-	1	-	2	-	1	-	1	1	1	2	2	1	-	10	3	16	11	8	5	-	6	1	41
Easthampton, . .	6	-	-	-	2	-	-	3	-	-	-	-	3	-	1	7	1	7	2	7	2	-	4	-	42
EVERETT, . . .	40	8	-	1	6	3	8	5	-	-	3	-	14	1	-	34	9	38	1	23	21	4	11	-	150

FALL RIVER, . .	169	2	16	36	44	24	14	4	5	-	6	1	273	8	23	177	85	105	303	85	60	4	53	12	714
FITCHBURG, . .	35	-	6	3	10	-	4	1	-	2	5	-	18	-	2	48	8	50	2	11	23	1	12	-	212
Framingham, . .	10	-	-	-	4	3	4	2	2	-	2	1	4	2	2	9	6	31	14	3	4	2	10	-	42
Franklin, . . .	4	-	-	-	1	-	1	3	-	-	-	-	1	-	-	7	1	15	9	5	3	-	-	-	22
Gardner, . . .	17	-	3	-	2	1	3	4	-	2	7	-	11	5	4	20	4	19	14	17	8	2	5	9	7
GLOUCESTER, . .	18	-	3	-	20	3	4	1	-	-	-	-	10	-	3	25	7	34	2	-	15	1	6	-	257
Grafton, . . .	5	-	2	-	-	-	-	1	-	-	-	-	5	1	1	9	1	4	-	1	1	3	2	-	23
Great Barrington, .	6	-	-	-	-	-	-	1	-	-	-	-	4	-	-	7	3	19	9	2	3	-	4	-	24
Greenfield, . .	6	-	1	-	1	-	-	2	-	1	-	-	2	2	2	15	2	8	8	13	9	-	7	8	18
HAVERHILL, . .	52	-	21	-	8	4	10	-	-	4	1	1	9	4	-	82	14	50	62	9	32	10	18	3	186
Hingham, . . .	8	-	1	-	-	-	-	-	-	-	-	-	-	-	-	4	7	11	14	6	4	1	7	2	27
HOLYOKE, . . .	86	-	4	2	23	-	8	2	-	-	8	-	58	7	54	60	21	43	67	44	25	6	28	-	208
Hudson, . . .	10	-	-	-	-	-	1	2	-	-	-	1	4	-	2	2	2	18	-	4	5	2	2	-	37
Hyde Park, . .	21	1	-	-	4	1	2	-	-	-	-	-	9	-	6	22	-	22	8	10	8	1	4	-	75
LAWRENCE, . .	118	4	11	6	13	18	11	1	-	-	-	-	88	2	11	153	41	59	70	29	35	3	27	10	453
Leominster, . .	23	-	-	1	3	-	2	2	-	-	-	1	10	1	10	14	2	20	3	14	13	2	4	-	46
LOWELL, . . .	164	4	8	5	76	12	16	4	8	1	8	1	107	3	10	200	77	219	35	77	57	9	61	-	773
LYNN, . . .	61	-	11	2	22	-	7	29	4	2	2	-	28	3	10	108	16	86	23	52	33	4	29	5	472
MALDEN, . . .	51	2	1	2	13	2	9	2	2	-	-	-	8	2	-	40	15	55	33	29	24	2	3	-	195
Marblehead, . .	11	-	-	-	1	-	-	2	-	-	-	-	-	2	-	9	2	19	11	3	10	4	1	-	42
MARLBOROUGH, .	17	-	-	1	22	-	1	11	-	-	-	-	3	-	-	16	3	37	-	6	4	-	3	1	71
MEDFORD, . .	17	1	-	-	1	1	3	1	-	-	-	-	9	-	-	16	11	28	-	2	9	1	2	-	114
MELROSE, . . .	18	4	-	1	1	2	1	-	2	-	4	-	2	-	3	16	3	17	21	8	10	2	5	12	67
Methuen, . . .	14	-	1	-	-	2	4	4	-	-	-	-	6	1	1	14	8	13	12	4	14	3	5	-	31
Middleborough, .	11	-	1	-	2	1	1	-	-	-	-	-	1	1	-	9	6	11	8	3	4	-	5	-	27
Milford, . . .	13	-	5	-	2	2	2	3	-	1	-	-	16	3	7	21	2	19	27	12	3	1	3	-	50
Milton, . . .	10	1	-	-	4	-	2	3	-	-	-	-	-	-	-	9	2	9	1	-	3	-	1	-	48
Natick, . . .	18	-	-	1	-	1	4	1	-	1	1	1	2	-	2	19	1	17	-	5	5	-	5	-	69
NEW BEDFORD, .	115	-	-	32	27	1	24	7	-	1	1	-	115	4	73	140	61	103	60	73	45	2	2	-	460
NEWBURYPORT, .	15	1	3	2	4	-	7	-	-	1	-	-	9	3	-	16	10	13	7	12	17	3	5	1	150
NEWTON, . . .	34	1	1	1	6	1	2	1	2	-	1	-	9	1	21	41	11	42	62	23	18	2	22	-	139
NORTH ADAMS, .	40	-	1	3	14	2	10	2	-	-	-	-	18	1	2	34	6	23	-	7	8	2	14	-	165

TABLE III. — *Concluded.*

	Consumption.	Small-pox.	Measles.	Scarlet Fever.	Diphtheria and Croup.	Whooping-cough.	Typhoid Fever.	Cerebro-spinal Meningitis.	Erysipelas.	Puerperal Fever.	Influenza.	Malarial Fever.	Cholera Infantum.	Dysentery.	Diarrhœa and Cholera Morbus.	Pneumonia.	Bronchitis.	Diseases of the Heart.	Diseases of the Brain and Spinal Cord.	Diseases of the Kidneys.	Cancer.	Suicide.	Accident.	Unknown or Ill-defined Causes.	All Other Causes.
NORTHAMPTON,	30	-	-	-	2	2	1	-	1	1	-	-	7	1	3	13	11	43	37	10	9	3	13	-	71
North Attleborough,	14	-	-	-	1	-	1	1	-	-	-	1	-	-	-	9	1	6	8	9	-	-	5	-	33
Northbridge,	4	-	9	-	-	1	-	4	-	1	-	1	5	-	2	11	5	11	3	5	3	1	2	-	28
Norwood,	3	-	1	1	1	-	2	1	-	1	-	-	1	-	3	2	2	9	8	3	-	1	4	-	12
Orange,	3	-	-	-	-	1	-	3	-	-	-	-	-	-	-	4	3	8	1	3	1	1	2	-	34
Palmer,	23	-	7	-	8	2	1	-	1	1	1	-	12	-	1	15	5	19	12	10	4	1	8	1	38
Peabody,	18	-	-	-	2	-	1	2	-	-	-	-	1	1	2	9	8	17	19	15	10	1	7	-	56
PITTSFIELD,	41	-	-	-	4	-	5	7	1	1	-	-	7	1	8	55	11	60	56	24	17	2	27	-	90
Plymouth,	16	-	-	-	2	-	2	-	-	-	1	-	4	5	1	4	3	33	27	10	16	-	3	-	44
QUINCY,	45	4	1	1	14	1	5	2	-	1	-	-	14	-	33	33	12	50	45	18	8	2	25	-	85
Reading,	8	-	-	-	-	-	-	1	1	1	1	-	1	-	1	6	3	5	2	2	5	-	6	4	19
Revere,	17	3	-	1	2	3	2	1	-	-	-	-	11	1	1	19	1	9	-	15	5	1	9	-	42
Rockland,	7	-	1	-	1	2	-	1	-	-	-	-	2	5	2	7	2	17	6	4	3	-	3	-	13
SALEM,	100	2	6	-	19	-	9	18	-	-	-	-	24	9	6	49	31	72	39	32	32	3	15	-	189
Saugus,	9	-	2	-	1	-	1	1	-	-	-	-	-	-	-	4	5	7	-	2	5	1	3	-	40
SOMERVILLE,	103	5	3	3	19	3	6	27	3	-	4	-	21	7	5	126	32	83	9	42	41	3	26	-	319
Southbridge,	16	-	1	-	2	-	6	5	-	-	-	-	10	2	-	27	2	17	11	8	5	1	4	-	41
Spencer,	14	-	-	-	1	-	-	-	-	-	-	-	-	-	-	5	-	15	-	3	4	2	2	-	42
SPRINGFIELD,	87	-	-	13	16	7	13	3	1	4	7	-	15	4	30	76	21	107	104	102	57	4	37	31	286
Stoneham,	22	-	-	1	-	-	1	1	-	-	-	-	1	-	1	11	6	12	18	9	9	1	1	4	17
Stoughton,	14	1	-	-	3	4	2	-	-	1	-	-	2	1	-	10	-	7	2	-	4	-	2	-	32
TAUNTON,	79	-	-	-	6	7	6	3	-	-	3	3	7	2	37	47	10	61	5	17	24	2	6	-	242
Wakefield,	24	-	3	1	-	-	2	4	-	-	-	-	1	-	-	14	8	19	18	13	11	-	4	3	22
WALTHAM,	39	-	-	4	5	-	9	-	1	-	-	-	1	-	-	42	6	33	29	9	23	1	-	6	118
Ware,	20	-	-	1	-	-	-	-	-	-	-	-	22	-	4	9	2	12	4	4	6	-	1	-	65

Watertown,	11	1	-	3	-	-	-	6	-	1	-	-	5	-	-	14	4	14	10	9	9	1	4	17	29
Webster,	9	-	1	12	8	3	2	4	-	-	-	-	8	2	3	18	4	2	-	1	3	-	2	-	82
Wellesley,	5	-	-	-	2	-	-	-	-	-	-	-	-	-	-	5	1	5	5	2	1	-	-	-	14
Westborough,	17	-	-	-	-	-	1	3	-	-	-	-	-	-	-	9	2	8	75	8	2	-	4	-	10
Westfield,	17	-	-	4	9	-	3	5	-	-	1	-	3	-	-	26	3	20	29	21	8	1	8	-	57
West Springfield,	5	-	1	1	-	-	-	1	-	-	-	-	4	-	-	11	1	10	1	6	4	1	6	-	46
Weymouth,	18	1	-	1	2	3	4	3	-	-	1	-	3	-	-	10	1	29	24	13	12	2	8	13	26
Whitman,	6	-	-	-	-	-	1	1	-	-	-	-	-	2	-	2	-	12	2	4	6	1	1	-	27
Williamstown,	5	-	-	-	-	2	-	-	-	-	-	-	-	-	-	2	2	6	9	1	3	-	-	-	14
Winchendon,	7	-	-	-	1	2	-	1	-	-	-	-	3	-	-	2	1	3	4	4	5	-	1	-	21
Winchester,	4	1	-	-	2	-	-	1	-	-	-	-	-	-	-	9	5	3	5	3	3	1	1	-	22
Winthrop,	3	-	-	-	3	-	-	-	-	-	-	-	-	-	-	6	-	10	7	1	4	-	1	-	6
WOBURN,	13	1	-	-	1	-	-	1	-	-	-	-	9	2	1	19	5	12	-	9	7	1	3	-	144
WORCESTER,	207	1	4	15	9	20	18	-	4	10	3	6	98	10	2	251	50	196	270	20	74	17	78	3	509
Totals,	4,090	279	229	283	803	241	469	348	111	80	107	38	1,512	176	926	4,015	1,172	3,901	3,040	1,844	1,726	255	1,348	409	13,024

	Homicide.
Andover,	1
Arlington,	1
BOSTON,	28
Brookline,	1
CAMBRIDGE,	2
Framingham,	1
HAVERHILL,	1
NEWTON,	1
Reading,	1

	Glanders.
BOSTON,	1
Rockland,	1

	Actinomycosis.
BOSTON,	1

	Rattlesnake Poison.
BOSTON,	1

	Malignant Pustule.
Greenfield,	1
NEWBURYPORT,	1

TABLE IV.

Deaths from Specified Causes, 1902, in Cities and Towns required to report to the State Board of Health, Death-rates per 10,000 (1898-1902), Deaths per 1,000 from All Causes, 1898-1902.

CAUSES OF DEATH.	Deaths. 1902.	MORTALITY PER 10,000 OF THE POPULATION.					DEATHS PER 1,000 FROM ALL CAUSES.				
		1902.	1901.	1900.	1899.	1898.	1902.	1901.	1900.	1899.	1898.
Consumption, . . .	4,090	16.38	17.63	18.56	17.91	18.41	101.06	104.58	101.60	103.70	107.01
Small-pox, ...	279	1.12	0.39	0.008	0.06	-	6.89	2.30	0.046	0.33	-
Measles, ...	229	0.92	0.73	0.99	0.66	0.34	5.66	4.35	5.44	3.80	1.99
Scarlet fever, . . .	283	1.13	1.46	1.51	0.84	0.53	6.99	8.64	8.29	4.85	3.09
Diphtheria and croup, .	803	3.22	4.40	5.87	3.99	2.74	19.84	26.13	32.12	23.08	15.94
Whooping-cough, . .	241	0.96	0.84	1.27	1.11	1.43	5.96	4.99	6.85	6.41	8.28
Typhoid fever, . . .	469	1.88	1.96	2.25	2.31	2.49	11.59	11.61	12.34	13.40	14.50
Cerebro-spinal meningitis,.	348	1.39	1.46	1.63	1.73	2.12	8.60	8.69	8.91	10.03	12.35
Erysipelas, ...	111	0.44	0.47	0.66	0.50	0.33	2.74	2.79	3.66	2.88	1.94
Puerperal fever, . . .	80	0.32	0.34	0.37	0.20	0.23	1.98	2.00	2.01	1.17	1.36
Influenza, ...	107	0.43	1.90	2.28	1.57	0.68	2.64	11.29	12.44	9.09	3.93
Malarial fever, . . .	38	0.15	0.19	0.22	0.21	0.30	0.94	1.14	1.23	1.20	1.76
Cholera infantum, . .	1,512	6.05	6.11	9.87	8.20	10.18	37.36	36.28	54.10	47.45	59.14
Dysentery, ...	176	0.70	0.72	0.75	1.00	0.94	4.35	4.25	4.12	5.79	5.45
Diarrhœa and cholera morbus.	926	3.71	3.54	3.84	1.84	2.44	22.88	20.99	21.00	10.67	14.16
Pneumonia, ...	4,015	16.07	16.66	18.40	17.89	15.08	99.21	98.83	100.70	103.60	87.66
Bronchitis, ...	1,172	4.69	4.47	5.09	5.18	5.60	28.96	26.50	27.88	30.00	32.56
Diseases of the heart, .	3,901	15.66	15.70	16.16	14.85	14.84	96.40	93.12	88.45	86.00	86.22
Diseases of the brain and spinal cord.	3,040	12.17	10.41	10.80	11.99	12.50	75.12	61.76	59.00	69.42	72.61
Diseases of the kidneys, .	1,844	7.38	7.75	7.32	7.13	6.57	45.57	46.01	40.05	41.30	38.17
Cancer, ...	1,726	6.91	6.19	6.53	6.06	6.32	42.66	36.75	35.75	35.07	36.70
Suicide, ...	255	1.02	1.05	0.99	1.07	1.06	6.30	6.22	5.39	6.18	6.16
Accident, ...	1,348	5.40	5.39	5.20	5.20	5.56	33.31	31.95	28.50	30.12	32.30
Unknown or ill-defined causes.	409	1.64	1.77	2.63	2.56	2.26	10.11	10.52	14.38	14.80	13.10
All causes, . . .	40,469	162.07	168.58	182.60	172.70	172.10	-	-	-	-	-

HEALTH OF TOWNS.

HEALTH OF TOWNS.

The following digest consists chiefly of extracts from the annual reports of the boards of health of cities and towns, illustrating the character and extent of the sanitary work performed by local boards of health.

During the year, the epidemic of small-pox, which had begun in 1901, continued to increase in severity until the disease had appeared during the year 1902 in 122 cities and towns. The details of the epidemic may be found in the general report at the beginning of this volume.

An increasing interest appears to be manifest in the necessity of making adequate hospital provision in cities and towns not yet provided with the proper means for isolating cases of contagious diseases, which cannot safely be cared for at their homes.

Reports of inspections made by Dr. F. L. Morse, medical inspector of the State Board of Health, may also be found in this section of the report, together with a table showing the visits and inspections made for the purpose of aiding cities and towns in controlling the spread of small-pox.

The following numerical statement of bacteriological work performed by local boards of health is also taken from the annual reports of those boards for the year 1902: —

Summary of Bacteriological Work in Massachusetts Cities and Towns in 1902, and by the State Board of Health.

	Throat Cultures for Diphtheria.	Examinations for Tuberculosis.	Examinations for Typhoid Fever.	Examinations for Malaria.	Packages of Diphtheria Antitoxin produced, of 1,500 Units each.
Boston,*	7,729	2,322	984	98	–
Brockton,	248	103	15	32	–
Brookline,	775	110	56	10	–
Cambridge,	2,103	215	263	–	–
Fall River,	262	–	45	–	–
Fitchburg,	254	90	81	–	–
Greenfield,	22	–	–	–	–
Holyoke,	422	–	–	–	–
Lowell,	2,201	141	211	2	–
Lynn,	727	–	–	–	–
Newton,	453	–	43	–	–
New Bedford,	269	64	5	–	–
Palmer,	216	–	–	–	–
Springfield,	763	–	–	–	–
Waltham,	881	25	Many.	–	–
Worcester,	1,266	–	–	–	–
State Board of Health,	2,904	928	217	61	33,475

* Boston, 140 examinations for glanders.

ARLINGTON.

The medical inspector has made daily visits to the various schools, and the following is his report: —

The total number of children examined during the year 1902 was 1,212, of which number 109 were sent home for the following causes: —

Pediculi,	46	Chicken-pox,	3
Vaccination,	18	Favus,	2
Sore throat,	19	Ivy poisoning,	2
Measles,	4	Stye,	3
Ringworm,	4	Erysipelas,	1
Pink eye,	3	Whooping-cough,	1

During the fall term 270 children were examined for vaccination, of whom only 18 were found unvaccinated. The latter were afterwards vaccinated and duly inspected.

In a number of suspected cases of whooping-cough the children have been requested to remain at home. These cases are not included in above list.

Several requests have been made by parents to have children's eyes tested for glasses, which requests have been complied with, with good results.

ATTLEBOROUGH.

But 3 cases of typhoid fever occurred during the year and but 1 death, which speaks well for the sanitary condition of the town.

One hundred and fifty-eight deaths from all causes occurred during the year, being about 15 per 1,000, 2 more per 1,000 than last year, but less than the average of towns of our size.

BELMONT.

Stagnant water in abandoned clay pits, when situated in close proximity to any well-populated district, is regarded as injurious to the health of the people living in its neighborhood, and within the last few years scientific researches have conclusively shown that such places are a direct menace to the health of the surrounding communities. With this fact before us, and realizing that an attempt might be made to utilize certain lands in our town for brick yards, in spite of protests already made by us, your board considered that some immediate action should be taken in order to prevent further extensions of insanitary clay pits.

Accordingly, at a meeting held on February 7, the following regulation in regard to the manufacture of bricks was duly adopted: —

REG. 19. The exercise of the trade or employment of excavating clay for the purpose of manufacturing bricks (except upon the premises now owned and operated by the New England Brick Company) is hereby prohibited within the limits of the town of Belmont, except in accordance with a written permit to be first granted by the board of health of said town.

Any person, firm or corporation desiring to exercise said trade or employment within the limits of said town must make written application for a permit to said board of health, subject to its approval, and must describe in said application the premises upon which the applicant desires to exercise said trade or employment, and must state the times when and within which the applicant desires to exercise said trade or employment, and also the depth and area of the excavation or excavations said applicant desires to make.

Said board will not grant such permit unless said applicant shall first furnish a bond with good and sufficient sureties (the amount of said bond, and said sureties to be satisfactory to said board), running to the town of Belmont, and conditioned upon the observance by said applicant of the terms of said permit, and also upon the filling in, within a reasonable time, to be fixed by said board, and with proper materials and in a manner satisfactory to said board, any excavation or excavations to be made by said applicant.

The following report of Dr. Morse, medical inspector of the Board, relates to an inspection made at Belmont on account of a limited epidemic of typhoid fever which had been reported from that town: —

On September 5 my attention was called by the board of health of the town of Belmont to a number of cases of typhoid fever which were appearing in the town. A visit was accordingly made, and upon investigation it was found that 6 cases of the disease had been reported within the past week, and that all of them obtained their milk supply from one milkman. He had accommodations for carrying on only a small business, which he personally attended to. The water supply at the barn was obtained from the public supply, while that at the house, in which the milk utensils were washed, was obtained from a dug well located under the back room of the house, and, apparently, capable of being polluted by the existing surroundings.

The milkman himself had, some months previously, been ill with typhoid fever, but he seemed to have entirely recovered at the time of the investigation.

A sample of water from the well was obtained, and upon examination found to be extensively polluted. A specimen was also analyzed bacterially, and 30 colon bacilli were found to each cubic centimeter.

The board of health of the town was informed of the results of these analyses and advised to have the well discontinued, and that all precautions be taken by the milkman himself to prevent the spread of the disease.

Boston.

The general health of the city for the past year, so far as it may be judged by the total mortality and its classified causes, has been better than the average for many years.

The total number of deaths for the year was 10,983, a decrease from the previous year of 317. The death-rate for the year was 18.73 per 1,000 inhabitants. This rate is the lowest on record.

Number of nuisances abated by owners or occupants of premises upon notice of the board of health during the year,	17,759
Disinfections practised: —	
In case of infectious diseases,	7,483
Rooms disinfected,	12,791
Places disinfected, streets, courts, yards, cellars, sinks, cesspools, closets, etc.,	77,943

Small-pox. — The presence of small-pox in Boston for nearly two years has been unusual, and has been possible particularly for two reasons: —

First. — There have been a large number of mild, unrecognized cases of small-pox in the city and suburban districts, going about from place to place, and

Second. — There has been a large percentage of unprotected people exposed to these unrecognized cases.

A serious drawback to our vaccinal protection against small-pox arises from the fact that Boston is practically a hot-bed of the anti-vaccine heresy, and although the vaccine house is built upon a rock, and is not likely to fall, the noisy storm has frightened many of our people into a dangerous neglect or opposition to vaccinal protection.

Hospital for Consumptives. — While it is gratifying to note the gradual diminution in the death-rate from consumption in Boston, it is nevertheless a source of regret that we are still without hospital accommodations for a large number of consumptive patients who are indigent, and also a menace to the public health.

Removal of Old Buildings. — More work has been done in the removal of old buildings during this year than was ever accomplished in any other year since the passage of the law in 1897.

During the year, the board has carried on this work to a great extent in the removal of old, worn-out and dilapidated sheds and ells, located in the rear yards of tenement houses, covering almost the entire yard space at the rear, thus depriving the main part of the house of the sunlight and air which it should have in order to ensure good sanitary conditions.

During the year 112 buildings and ells and 49 old sheds have been removed.

Tenement Houses. — The inspection, alteration and renovation of the tenement houses of Boston has been continued this year, and a great deal of work has been done in the way of providing more light and ventilation for dark bed-rooms, and in lighting, ventilating and relocating water-closets.

The board begs to renew its recommendation that the tenement house law be so changed as to include three-family houses, as they need supervision fully as much as those for four families.

Medical Inspection of Schools. — Summary of diseases found among scholars in school: —

Specific infectious diseases,	326
Oral and respiratory diseases,	1,924
Diseases of the ear,	105
Diseases of the eye,	547
Diseases of the skin,	3,795
Miscellaneous diseases,	7,795
Found free from disease,	3,793
Total,	18,285

Number of pupils examined in the schools,	18,285
Number recommended to be sent home,	2,649
Number of consultations with teachers (about pupils returning to school, etc.),	2,963

The Report of the Director of the Bacteriological Laboratory. — The work of this department of the board is fully reported, and shows much original as well as routine work.

The routine work embraced the following examinations of material for detecting the presence of infectious diseases: —

Diphtheria cultures,	7,729
Tuberculosis,	2,322
Typhoid fever,	984
Glanders,	140
Malaria,	98
Other diseases,	32
	11,305

The special investigations related to: —

1. The comparative morphology of the diphtheria bacillus.

2. Experiments in disinfection with formaldehyde gas and carbolic acid vapor.

3. The distribution of the bacilli of tuberculosis and diphtheria in rooms used for the isolation of these diseases.

4. Drying experiments with certain bacteria.

5. The distribution of dangerous mosquitoes in Boston.

Animals killed at Abattoir. — Cattle, 27,419; calves, 22,304; sheep, 17,270; swine, 3,292; total, 70,285.

Of the 27,419 cattle received for slaughter, 250, or less than 1 per cent., were found to be tuberculous; 3.5 per cent. of the cows received from eastern States were tuberculous, and only 2 animals from the western States out of 8,042.

Glanders was reported to the board, 162 horses having been examined and 121 found infected with glanders.

The foot and mouth disease appeared in only one herd in Boston.

BROCKTON.

Formaldehyde disinfection of rooms and bedding, etc., after contagious diseases, has been continued as heretofore.

The board again strongly advises the establishment by the city of a contagious disease hospital, where persons affected with dangerous diseases of an infectious character may be isolated and properly treated, and the utmost precautions be taken against an epidemic. It seems that the matter of establishing such a hospital as the board advises has an economic as well as humane and politic side.

The laboratory for bacteriological work, established by the board at the filter-beds of the sewerage department, has proved an immense boon in the work of detecting and arresting disease in its incipiency, and has been the means of a saving to the city, the old system of sending cultures to Boston for examination being expensive and time-taking.

A most striking and suggestive illustration of the value of the local laboratory was shown in the case of a teacher of the public schools. She was taken ill on Saturday, and on Sunday the attending physician took a culture and found diphtheria bacilli, and placarded her house. The school also was closed. Had the culture taken from this teacher been sent to Boston, as would have been necessary in former times, her pupils would have been exposed to the disease for at least two days.

The board would once more protest against the inefficiency of the present system of milk inspection, believing that an impure supply can only be properly guarded against by compelling all dealers coming into the city to submit their supplies to chemical analysis, under the direction of the board, at least once a month.

BROOKLINE.

It is proposed to continue the war upon mosquitoes which was vigorously waged last year. While there were undoubtedly less mosquitoes than usual in Brookline last summer, the same thing was true in a neighboring town where nothing was done to diminish their numbers, so that too much must not be claimed as the result of the work done here. It is not the intention of the board to undertake an extensive scheme of draining private lands, but reasonable efforts will be made to induce land owners to do away with unnecessary standing water, affording breeding places for mosquitoes.

It is now generally agreed by physicians that infected persons, rather than sewer gas, leaks in pipes or filthy substances, cause infectious diseases to spread, and that they are best checked by isolation, and by such sanitary inspection and health regulations as tend to personal cleanliness. It should not for a moment be supposed, however, that disorderly or filthy premises, defective plumbing or overcrowded sleeping rooms can be tolerated.

The new hospital buildings were completed early in the summer and are now occupied, excepting the pavilion for diphtheria patients.

From Oct. 11, 1902, to Jan. 31, 1903, 21 scarlet fever patients, 13 diphtheria patients and 2 patients ill with both diseases at once have been admitted to the hospital. Of the total number, 36, all recovered, except one of the scarlet fever patients.

The new hospital arrangements prove very satisfactory to those in charge, and the safety and comfort of the patients have undoubtedly been greatly promoted by the many modern improvements that have been introduced. A few private patients with either scarlet fever or diphtheria can now be taken care of at the hospital.

The importance of certain precautions in preventing infection among school children is so great that in October, with the approval of the medical members of the school committee and the superintendent of schools, the following circular was put in the hands of all the regular teachers except those of the high school: —

To the Teachers of the Brookline Public Schools.

Your attention is called to the following report of a special committee of the Massachusetts Association of Boards of Health, on teaching cleanliness among school children: —

At the annual meeting in Boston, in January, 1901, a special committee was instructed to draw up a circular of advice relating to cleanliness in school children, and especially designed to prevent infection from one to another by intimate and thoughtless contact between one another and their belongings. A meeting was held for this purpose April 24, at the State House, in the rooms of the State Board of Health. Members of the committee present: Dr. Charles V. Chapin, chairman; Dr. Samuel W. Abbott, Dr. Theobald Smith, Dr. Francis P. Denny and Dr. Hibbert W. Hill, secretary. A report and circular were prepared and accepted by the association at its next quarterly meeting.

Report of the Committee.

It appears to the committee that at times a considerable number of children are infected with communicable disease, though they may be very slightly sick or even not sick at all. Such children mingle freely with others, and are, according to our present knowledge, the most fertile cause of the spread of communicable disease. If the communication between mouth and mouth can be prevented, it is believed that communicable disease (especially diphtheria) may be diminished. The schools seem to be proper places for inculcating that personal neatness and cleanliness which would forbid the passage from mouth to mouth of any article. The means suggested for the accomplishment of this object are: —

(1) The instruction of teachers by an annual lecture or talk. The teachers' institute furnishes an excellent opportunity for this.

(2) The distribution annually to teachers of a circular, a model for which is hereby presented.

(3) If the town or city desires cleanliness and refinement taught, it must itself teach by example.

The free text-book system presents some obstacles to the development of the idea of privacy of personal property, but with care they can be overcome. Even with this system the pupil can in most instances have his own books and pencils for a term or year, and be held responsible for their condition. This should always be done so far as possible with everything that is furnished by the school department for the use of pupils. It entails more trouble for the teachers, particularly in the care of pencils, pen-holders, etc., but with a proper system and some care these may be kept separate for each child. When books become decidedly soiled they should be burned.

The use of modelling clay, if it is passed from one pupil to another, is objectionable, as it certainly gathers dirt from the hands; but if each pupil's clay is kept separate, as it is done in many schools, its use may be permitted. The drinking cup is perhaps the most common means of transmitting saliva from one child to another, and its use should be abolished. Separate drinking cups might be provided, either by the pupils or by the school department. The use of a special style of drinking fountain, to be used without cups, has been recommended, but with this the committee has had no experience.

Suggestions for the Teaching of Cleanliness among School Children.

The poisons (germs) of some of the common and also of some of the most loathsome diseases are frequently contained in the mouth. In such cases anything which is moistened by the saliva of the infected person may, if it touches the lips of another, convey disease. The more direct the contact the greater the danger. It is the purpose of health officials to keep in isolation all persons having dangerous communicable diseases during the time that they are infectious, but in many cases this is impossible. Little restraint is put on certain mild diseases, — measles, whooping-cough, chicken-pox and mumps, — and even such diseases as diphtheria, scarlet fever, varioloid and tuberculosis are frequently so mild as to be unnoticed; and children affected with them mingle freely with others. It is probable that in such cases one of the chief vehicles of contagion is the secretion of the mouth and nose. It is believed that much can be done to prevent contagion by teaching habits of cleanliness. *If such instruction is to be effectual it must be continuous. The teacher must notice and correct the violation of these rules as habitually as the violations of the most formal school rules.*

Even if the question of disease and contagion did not enter into the matter at all the subject ought to be given more attention by teachers. Our schools should not only teach reading, writing and arithmetic; it is quite as important that they should inculcate cleanliness, decency, refinement and manners. Cleanliness should be taught for its own sake, even if it had no relation whatever to health.

Teach the Children

Not to spit; it is rarely necessary. To spit on the floor or sidewalk is an abomination.

Not to put the fingers into the mouth.

Not to pick the nose.

Not to wet the fingers with saliva in turning the leaves of books.

Not to put pencils into the mouth, or moisten them with the lips.

Not to put money into the mouth.

Not to put pins into the mouth.

Not to put anything into the mouth except food and drink.

Not to "swap" apple cores, candy, chewing gum, half-eaten food, whistles or bean blowers, or anything that is habitually put into the mouth.

Kissing is a means of transmitting infection.

Teach the children to wash the hands and face often, and to keep the nails and teeth clean. If the child is coming down with a communicable disease, it is reasonable to believe that there is less chance of infecting persons and things if the hands and face are kept clean and not daubed with the secretions of the nose and mouth.

Teach the children to turn the face aside when coughing or sneezing, if they are facing another person.

See that the hair is free from every trace of pediculosis (lice).

Children should be taught that their bodies are their own private possessions; that personal cleanliness is a duty that they owe to themselves and to their companions; that the mouth is for eating, drinking and speaking, and should not be used as a pocket; and the lips should not take the place of fingers.

CAMBRIDGE.

Medical Inspection of Schools. — The diseases discovered in the schools and the number of cases were as follows: —

Chicken-pox,	22
Measles,	3
Mumps,	12
Pediculosis,	166
Scarlet fever,	1
Whooping-cough,	28
Diseases of ear,	8
Diseases of eye,	92
Diseases of nervous system,	7
Diseases of respiratory system,	5
Diseases of the skin,	84
All other diseases,	309
Total,	737

The epidemic of small-pox which broke out in Cambridge in October, 1901, continued with increasing severity during the spring months of 1902 and then died away during the following summer.

At the stations for free vaccination 5,793 persons were vaccinated during the autumn of 1901; 2,745 persons were vaccinated at these stations in 1902. When compulsory vaccination was ordered by the board of health, and public vaccinators were sent from house to house, 21,685 more persons were vaccinated. A communication was also addressed to the physicians of the city inquiring how many persons had been vaccinated by them in their private practice. Replies were received from about two-thirds of the physicians addressed. These replies showed that 25,990 persons had been vaccinated in Cambridge by these physicians.

A very carefully prepared report by the medical inspector accompanies the report of the board.

Dedham.

The value of vaccination is again strikingly shown in the 3 cases now existing in the town. In the case of the vaccinated patients the cases are extremely light, in the unvaccinated patient, very severe, resulting in death.

Easton.

The board earnestly recommends the establishment of a small contagious hospital, where cases of infectious disease may be treated in a more economical manner, and with a greater degree of safety to the community.

Fall River.

A hospital for contagious diseases is a necessity that should be provided at as early a date as possible.

The board should be given the means to place medical supervision over the schools of the city without being compelled to do so as an emergency measure whenever occasion arises.

We should be given an appropriation to enable us to employ one or more physicians to attend to the work of the board, such as diagnosing suspicious cases, treating small-pox and contagious diseases at the temporary contagious hospital and determining time of fumigation in cases of scarlet fever and diphtheria treated outside such hospital, and to enable the board to add the work of testing sputum for tuberculosis to that of bacteriologist, as well as such other means as the medical fraternity and health boards elsewhere are advocating and practising in combating this justly most dreaded of diseases.

An inspector of meats, provisions, fruits and vegetables is much needed in this city.

The mode of procedure in small-pox cases which has been found efficient in this city for the past two years is as follows: —

When a case is reported to the board the official diagnostician is sent to examine it, and if it is found positive the house is placarded in various languages and guards put on duty to prevent any person from leaving the house or any person except *bona fide* residents or health officials from entering it until after the patient is removed, all persons residing therein who require it vaccinated, and the premises disinfected, after which the guards are dismissed, and all adults allowed to go and come at will, but no person is permitted to remove or change residence until after the period (sixteen days) in which any person affected with the disease would develop it. A list of all adults is taken, and if working their employers are notified and allowed to use their discretion about keeping them employed, and the diagnostician visits the place frequently during the following sixteen days, when, if no other cases occur, the premises are again disinfected and the placards removed. All school children and minors unemployed are prohibited going outside further than the yard during the time the placards are on the house, which will be continued sixteen days after the appearance and removal of the last patient in the event of any case occurring subsequent to the first case.

A record is also made of the names and addresses of all persons found to have been exposed by visiting residence of the patient within sixteen days previous, and these are also kept under surveillance and visited by the physician at fixed intervals during the sixteen days following the date of their last exposure.

FITCHBURG.

Public sanitary matters have been acted upon by the board, after full discussion, along the lines of the best for the greatest number. Quarantine regulations could have been more satisfactorily enforced if the city had an isolation hospital for diphtheria and scarlet fever. Several years ago the annual report of the board stated that "good isolation is impossible in at least one-half of the cases where it is needed the most, and therefore a contagious disease hospital is imperatively demanded, and we ask that one be provided at the earliest moment." Until such a building is provided, quarantine cannot be properly established without some injustice to the families concerned.

HOLYOKE.

The board would once again call attention to the imperative need of a hospital for the care of diseases of a contagious nature, especially diphtheria and scarlet fever. The value of such institutions is being realized more and more each year, and many of the cities of the State now have such accommodations, which greatly aid in the control of epidemics of such diseases. With our large tenement districts, it is evident that we should have such a building at our command in this city.

HYDE PARK.

There were fewer cases of diphtheria than in 1901, and a smaller death-rate also, and it is safe to say that the low death-rate from this dread disease is due to the free use of antitoxin, which is furnished to us by the State Board of Health; and we feel that any act or acts of the Legislature that would prevent the State Board of Health from supplying the people of this State with what is now generally conceded to be a specific remedy for diphtheria, would be a hardship which they should not be called upon to endure.

IPSWICH.

The general health of the town has been exceptionally good during the year and no serious epidemics of contagious diseases have occurred. The sanitary condition of the town the board considers generally satisfactory, complaints of nuisances being very few.

Lawrence.

For the past six or seven years the board has steadily advocated and urged upon the city government the great necessity of a contagious disease hospital, and we are much pleased that a hospital has been erected and partially completed during the present year for the isolation and care of persons sick with small-pox.

The new hospital has been furnished with apparatus and furniture sufficient for ordinary requirements, and with proper attendants about fifteen patients can be conveniently cared for, and more could be accommodated if occasion should require. The needs of a small-pox hospital for all cases likely to occur under ordinary conditions would seem to be now well supplied. But there is still a pressing need of a hospital where diphtheria, scarlet fever and measles may be cared for without peril to the sufferers or the public. Frequently, contagious diseases break out in boarding houses and tenement blocks, and for want of a proper place to remove the patients to they are compelled to remain, to the great peril and inconvenience of other occupants. All the children in a large block are frequently barred from school for several weeks on account of one case of contagious disease. With a proper hospital for their reception the patients could be removed where they would receive excellent care.

Lowell.

Our sanitary inspection is carried on systematically, and includes examination of conditions of cleanliness, plumbing, drainage, water supply, garbage disposal and causes of illness; and to make it fulfil its highest possibilities, it should be sustained by an enlightened public opinion, nonpartisan health officers and ample appropriations.

Prevention costs less than cure, and any work that tends to arrest the progress of disease should have the good-will of those who temporarily hold the purse strings of the municipality.

During the year 1901 Lowell had a very large number of cases of diphtheria. It continued with increasing virulence during the first month of 1902, 120 cases, the record height for any one month in the year 1902. Total for 1902, 654 cases.

Sunday, January 26, following an examination of the inspector's reports, it was found that in 8 cases of the day previous the families were served by the same milkman, whose supply depot was in an adjoining town.

This seemed to be an important discovery, and the milk inspector with the department bacteriologist were sent to the home of the milkman, in order to ascertain if there was any reason to suppose him to be the source of infection. They found the place and the method of distribution above suspicion, but the proprietor had been unwell for several days with a sore throat, and his assistant was wearing a cloth around his throat, which had troubled him for some time. On being questioned, it was found that both had consulted a local physician, but as he saw no patches he diagnosed the trouble as tonsilitis. Cultures were taken from both throats and they were found to contain diphtheria germs. They both stopped at once the delivery of milk, and all cans and receptacles on the route were collected and thoroughly washed and sterilized.

Following this discovery, a number of milkmen were examined by culture but all were found in a healthy condition. From January 26 to February 6 43 cases of diphtheria were traced to the personal exposure or the milk supply of this vendor.

LYNN.

There has been no general epidemic in the city as compared with some. When we consider in a city of 72,000 inhabitants there have been only 12 cases of small-pox and no deaths, and that 10 of these cases came from one source, we are very fortunate, to say the least. Lynn's death-rate is the lowest of any city of her size in the State, her hygienic conditions are of the best; we have pure air and good water and plenty of it. But with all this in our favor there is only one way to stamp out, and keep out, the foulest of contagious diseases, small-pox. This can be done by vaccination alone.

NANTUCKET.

Following is the report of the medical inspector, Dr. Morse: —

During the early part of the fall information was indirectly received at this office from Wrentham in regard to a number of cases of typhoid fever existing in that town, it being supposed that the disease was contracted at Siasconset, a summer resort upon the island of Nantucket. As a result of this information a visit was made to Siasconset on September 26 to investigate the existing conditions, and to determine, if possible, the source of infection.

Up to this time only 4 cases of the disease had been brought to our attention, but upon interviewing Dr. Roberts, a summer resident of Siasconset, we were able to learn of many other cases which existed during the summer season and which had not been reported to the local board of health as required by law. The excuse was that the cases were not typical of typhoid fever, that they were mild in character and probably due to another infection than that of the typhoid germ.

It was the intention at the time of the beginning of the investigation to obtain a list of all of the guests at the Ocean View Hotel at this resort, at which place all of the patients ill with the disease stopped, and it was stated that the hotel register would be available at the hotel when we visited it; but the register for this year was not in the office, and those who were connected with the hotel at the island did not know where it was. The manager of the hotel was later interviewed in regard to the register, and stated that it had been left there at the close of the season and he was not able to tell where it could be found at that time. He did, however, furnish a list of about 40 names of people who were guests at the hotel during the summer and stated that these names practically represented 200 persons. It is estimated that during the summer season between

700 and 800 guests were accommodated at the hotel, so we have been able to interview directly hardly one-quarter of those who spent their vacations there.

From these three sources we have been able to learn of nearly 30 cases of typhoid fever appearing among the guests of this hotel, and from inquiries made at the time of the visit to Siasconset among the residents there and from Dr. Roberts we are unable to find any other cases developing among those who did not stop or take their meals at the hotel. So it seems that the source of infection must exist at the Ocean View Hotel.

Up to this year typhoid fever had hardly been known or spoken of at this resort, but early in June, when the hotel opened for the summer business, one of the first guests to come was a man from New York, who had been ill with typhoid fever and was convalescent at the time of his arrival. The next case to appear was the housekeeper of the hotel, who was taken ill on July 8. The pastry cook was taken ill on July 15; the steward on August 12; a waitress on August 14, and the watchman on August 24. Following these, up to September 8, 7 other cases appeared, 5 of them among guests, the two others being the clerk and head waiter of the hotel, and following the return of the guests to their homes 12 other cases appeared. It would seem from the history of these cases, appearing at irregular intervals throughout practically the entire season, that the source of infection was present all of the time, instead of having one specific source of infection present for only a limited time, and when we examine the water supply at the hotel we find the probable source of infection.

Up to this season the water supply was obtained from a dug well twenty-six feet deep, located in a small engine room on the easterly side of the building and walled on the inside. Soon after the hotel opened in June the sides of this well caved in, and it was necessary to obtain a new supply, which was done by driving a small galvanized iron pipe thirty-one feet below the surface of the ground into the bottom of the old dug well. While this was being done a temporary supply was obtained for the use of the hotel at the town pump, some distance away, and an analysis of this supply was made during the middle of the summer, and upon examination it was found to be dangerously polluted. On account of the location of this driven well it is exposed to many possible sources of pollution. A pipe which conveys the sink water from the kitchen to a cess-pool about one hundred and fifty feet from the well, and at a lower elevation, passes within ten feet of the well. A cess-pool with plank sides and an earth bottom, receiving the sewage from the water-closets at the hotel, is located sixty-three feet from it and upon a higher elevation. A privy with an uncovered vault, used by the employees at the hotel, is located about ninety feet from the well upon a higher elevation and draining towards the well, and the yard about the building had a decidedly unclean appearance at a time when the cleaning-up process had been completed. The water from this well was pumped by a steam engine to the rooms of the hotel itself, and also into a coverless wooden tank located in a room on the top floor of a building called the Annex, and was supplied to the different floors under this pressure. The room in which the tank was located was used as a store-room by the servants of the hotel, and it contained slop pails, and a sink into which, apparently, slops were turned. The Annex contained sleeping apartments for those who boarded at the hotel.

The probable source of infection is, apparently, the use of the well water, and it seems possible, on account of the fact that the housekeeper, the pastry cook and two waiters had the disease, that the infection may in addition have been transferred directly to the food eaten by the guests.

A sample of water was obtained from the driven well and upon examination it was found to be polluted to a considerable extent.

During the summer, after the town pump water had been found upon examination to be polluted, a new well was driven about fifteen feet distant from the old well, and a sample of water collected at the time of my visit showed this supply to be even more polluted than the old one, the location of the well being only about fifteen feet distant from a privy which was in constant use. Other samples of water were obtained from supplies located in other parts of the village, and the results of the analyses from these wells show them to be, with but two exceptions, seriously polluted and unfit to use for drinking purposes. One of these wells is that located at the Beach House and the other one upon the estate of Dr. Harrison Allen, on Atlantic Avenue, both being driven wells.

It would seem necessary, before the opening of another season, that some measures should be taken by the town of Nantucket to obtain a good water supply and a proper system of sewage disposal for the houses and hotels which are located at this resort. They are, for the most part, within a limited area or huddled together, each house having its individual well, constantly exposed to the drainage, not only of their own houses, but of those immediately surrounding. It would seem possible, in the opinion of the engineer, to introduce a water supply and a sewerage system at comparatively slight expense which would supply the inhabitants of the resort and would prove of great benefit to the place as a summer resort.

Newton.

During the year over 40 suspects were visited by the board, and of this number 22 proved to be small-pox, while the remainder were examples of disease over which the board has no control. It is this willingness to report even doubtful cases as soon as seen, instead of waiting until the disease has declared itself, that has enabled the board, in almost every instance, to get control of the real cases at the earliest moment.

In almost every case where the patients have been ill for several days before the board has been aware of the fact investigation has shown that the delay was due to a failure to call a physician.

That Newton has not had a severe epidemic of infectious disease for many years is undoubtedly due to the promptness with which the reports are sent in by the physicians, who are, after all, unofficial and most valuable medical inspectors.

The outbreak of small-pox which occurred during the closing months of 1901 continued during the present year, and Newton had its share of cases. The beginning of the year saw the small-pox hospital with but 1 case in the wards, but other cases were reported from time to time, and before the year ended 22 cases had been reported, with 1 death, a mortality of 4.54 per cent. By far the greater number of cases occurred in unvaccinated persons, 17 out of the total stating that they had never been vaccinated or else showing no visible scar. Several of the patients said that they had been vaccinated, but showed no scar, and careful questioning failed to establish proof of a successful operation. They gave no history of a sore arm, and the vaccination was evidently a failure. In this connection it is proper to state that many persons will say that they have been vaccinated when in reality all that they have done was to submit to an inoculation which failed to "take." This, of course, does not constitute vaccination in the proper sense of the term, and is absolutely useless for protection against small-pox.

It is well to repeat the inoculation after any known exposure to infection in order to make "assurance doubly sure." Repeated vaccination has been the practice among those members of the board whose duties led to frequent exposure. When the inoculation did not "take" it has been repeated as often as once a week until a successful result was obtained, or the liability to infection ceased. As a result of this practice no member of the board nor any employee or nurse contracted the disease, although repeatedly exposed to infection.

With the beginning of the present year the board discontinued the old custom of segregating and quarantining the inmates of a house from which a case of small-pox had been removed. It was felt to be a great and unnecessary hardship to confine to the house for two weeks well persons whose misfortune it was that a member of the household had contracted small-pox. As these persons were well themselves, it was impossible for them to be dangerous to others provided they were properly disinfected. For this reason the following procedure was adopted: the house where the disease had appeared was thoroughly disinfected, all persons living in the house were vaccinated, the clothing which they wore at the time the disease was present disinfected, and they were allowed to go. They were warned to call in a physician if they felt in the least ill, and they were visited occasionally during the time when they might be expected to show symptoms of the disease. In case vaccination was refused the exposed person was quarantined for two weeks.

The board was blamed somewhat when the public learned that the quarantine of suspects had been discontinued, but no evil results followed the change, and the board feels that the correctness of its position in the matter has been demonstrated.

The new infectious disease wards have accommodations for twenty-five patients each, giving a total of fifty beds, which should be ample for the needs of the city for many years to come.

North Attleborough.

The persistent pollution of the Ten Mile River, making it the receptacle for so much sewage of the town, must ultimately become so obnoxious as to constitute a source of filth, with its disease-spreading influences. The question has been raised, whether the clearing out of the bed of the river would not relieve this threatening condition for many years. As a committee has been appointed for the investigation of this question, the board of health awaits the report of this committee without expressing an opinion either pro or con.

As the effect of using the stream for a sewer will be more apparent and obnoxious during the dry season the board of health entered a protest against the use of the river as a cess-pool by a laundry company. The only course open to the board was to inform the party that, in case any complaint should arise from such use of the river, all connections with the stream must be closed within twenty-four hours.

Palmer.

Upon application the State Board of Health has kept us well supplied with antitoxin, and its general use by the physicians of the town in diphtheria has been rewarded by very few deaths when compared with the number of cases reported.

Plymouth.

It is gratifying to the board to note that the town voted at its last meeting that all premises on the line of the public sewer should be connected therewith within a reasonable length of time. It is not always easy to enforce the regulations which the board deems necessary for the public good, and it is encouraging to have such an assurance of support.

The water of the Elder Brewster or Pilgrim Spring is kept under surveillance and occasionally analyzed on account of the opportunity for contamination which its location affords, but it continues to remain pure in the estimation of the State Board.

The following report relates to an inspection made at Plymouth by Dr. Morse, medical inspector, on account of an epidemic of typhoid fever which had been reported from Plymouth: —

During the early part of October my attention was called by the board of health of the town of Plymouth to a large number of cases of typhoid fever which had occurred during the preceding weeks, and it was asked that an investigation be made in order to determine the origin of the disease. A visit was made to the town and 12 patients were visited, with the view of ascertaining the source of infection Of these cases, 7 lived in one house, and it was learned that the first patient was a child thirteen months of age, who had come to the town ill with the disease on September 5, and from the fact that the child's mother and sister had it at home, it is reasonable to believe that he contracted it from them. The disease was unrecognized in the early part of the illness, they employing no physician and there being no steps taken towards disinfection to prevent the spread of the disease. On October 10 another member of the family was taken ill; on October 13 two others; on October 18 two more, and on October 23 the sixth case occurred in this family.

The water supply was obtained from the public system and the milk from Mr. Beckford, but there is no reason to suppose that infection was obtained from either of these sources, and the disease was probably transmitted directly from one member of the family to another on account of the lack of the usual precautions that are taken in such cases.

Of the remaining 5 cases, 1 came to Plymouth from Chicago and was ill with the disease when he arrived. Another had visited out of town for several days and it is not possible to state the origin of her illness. The third was an electric lineman, working a large part of the time upon country roads and drinking water from any available source.

Eliminating these cases, it is apparent that the town of Plymouth did not have an unusually large number of cases of the disease present for that time of the year, and the board of health was informed of this conclusion.

REVERE.

At the present time we have but four piggeries in Revere, two having been abolished because of the filthy manner in which they were maintained.

As the population of the town is rapidly increasing, we believe it is but the question of a short time before these institutions will all have to give way to the improvement of the town and go beyond its limit to some less thickly settled locality.

SALEM.

The board are firmly of the opinion that antitoxin is the greatest known remedy for diphtheria, but it *must* be used *in time*, and *freely*.

The board feel it again a duty to call attention to the law concerning contagious hospitals and the great want of Salem in this direction.

SOMERVILLE.

Number of nuisances abated,	794
Number of nuisances referred to board of 1903,	79
Number of nuisances complained of,	873
Number of complaints (many covering more than one nuisance),	460
Number of notices mailed,	723
Number of notices served by constables,	41

In addition to the above, 232 dead animals have been removed from the public streets, and many nuisances have been abated on verbal notice from the agent, without action by the board, of which no record has been made. Each spring the whole city is examined, and cellars, yards and alleyways where rubbish and filth have collected are required to be cleaned.

Glanders. — Fifty-six cases of glanders have been reported during the year. Prompt action was taken in every case, and 51 of the horses were killed, 5 being released from quarantine by order of the Cattle Commissioners.

By special request of attending physicians the agent has disinfected rooms that have been occupied by patients with consumption, typhoid fever and cancer. He has also disinfected a large number of library books, and has burned a quantity of infected bedding and other material.

SOUTHBRIDGE.

During the months of April, May and June the town was visited with an extensive epidemic of small-pox. Forty cases of that disease occurred in Southbridge during the year. It is greatly to be regretted that early in the epidemic there were those who did not realize the necessity for strict quarantine, and were induced, from motives best known to themselves, to interfere with the efforts of this board to stamp out the disease. Professional incompatibilities, in which we cannot think the people generally have much interest, and which most certainly ought to have nothing to do with sanitary regulations, seem to have operated to hinder and obstruct the board of health in carrying out its proper and required work. Finally a general vaccination was ordered, which effectually put an end to the contagion.

SPRINGFIELD.

Recognizing the danger of conveying infection by the careless use of the tools and utensils in barber shops, the following regulations were adopted by the board in February: —

> The place of business, together with all furniture, shall be kept at all times in a cleanly condition.
>
> Mugs, shaving brushes and razors shall be sterilized in boiling water after every separate use thereof.
>
> A separate clean towel shall be used for each person.
>
> Alum or other material used to stop the flow of blood shall be used in powdered form and applied on a towel.
>
> The use of powder puffs is prohibited.
>
> The use of sponges is prohibited.
>
> Every barber shop shall be provided with running hot and cold water. No person shall be allowed to use any barber shop as a dormitory. Every barber shall cleanse his hands thoroughly immediately after serving each customer.
>
> Hair brushes and combs shall be thoroughly washed, at least once a day.

The above regulations have been printed on cardboard hangers and distributed to each barber shop.

Continuing the custom inaugurated last year, free vaccination has been offered every Saturday morning at the office of the health department. Printed cards of instructions as to the proper care of the arm are given to each person, and certificates of vaccination are given upon the return of the patient with evidence of a successful operation.

WAKEFIELD.

The following report of Medical Inspector Morse relates to an epidemic of typhoid fever at Wakefield which apparently was traceable to pollution of the public water supply of the town: —

On September 15 my attention was called by the board of health of the town of Wakefield to the existence of a large number of cases of typhoid fever which had occurred in the town during the preceding two weeks, and it was asked that an investigation be made as to the cause of the disease. A visit was accordingly made to the town and 20 patients ill with the disease were visited, and information obtained relating to the source of the infection. Of these cases, 3 were ill about two months previous, all members of one family. The water for drinking was obtained from a well at their own house. One was ill in the early part of August, and from the history obtained it is reasonable to suppose that she contracted the disease while away from home. Of the remaining 16, all of them went to bed between the first and eleventh of the month. They had variable milk supplies, one dealer conducting a large business having 5 cases upon his route.

All of these patients obtained their water from the public supply, and attention was next directed to possible existing sources of pollution. The water supply of the town is supplied from Crystal Lake, situated only a short distance from the thickly populated part of the town. An extensive ice business is carried on at the easterly end of the lake, and during the summer season a trunk sewer was being constructed along the edge of the lake for a considerable distance. It was the custom of the contractors to pump the water collecting in the sewer trench into a wooden trough, from which it flowed directly into Crystal Lake. Strict orders had been issued by the superintendent in charge that no nuisance should be committed by the laborers upon the work, but it was known that such conditions did exist, for several of the laborers were discharged as the result of disobedience of this order. An analysis of a sample of this water taken on September 16 did not show any marked variation from the usual character of the water, but a sample obtained a few days later showed the presence, on analysis of colon bacilli.

The board of health of the town was informed of the probable source of infection and advised to warn the people to boil all water before using for drinking purposes, and the water company was asked to have the sewer trench water diverted from their supply.

During the following ten days 5 other patients became ill with the disease, which apparently ended the epidemic, as no other cases were reported until the latter part of October, when 2 cases occurred, which, however, could not be attributed to this infection.

WALTHAM.

Except for an epidemic of measles the city has been unusually free from infectious diseases during the year.

About six hundred complaints, varying in their nature, have been received during the year. All complaints have been investigated and such measures adopted as conditions seemed to warrant.

An examination of many of the dairies in this city and in neighboring towns where our milk is produced has been made.

WARE.

That the general sanitary condition of the town improves each year is indicated by the fewer number of calls to abate nuisances which the sanitary inspector receives, and the past year has been particularly noticeable in this respect. Discarding the old privy vaults and wells and the more careful attention given to the cleanliness of premises have done much towards this result.

WATERTOWN.

By vote of the town sufficient appropriations were made to build a new isolation hospital, which is much better for its contemplated purposes than any structure heretofore possessed by the town.

Twelve or more patients may be accommodated at the same time, and there are two wards for the sexes, each separate and distinct from the other. There are accommodations also for the doctor, nurse and housekeeper. One of the features of the hospital is the dead wall, which separates the contagious from the living wards of the hospital. A fence has been built, which serves to screen from the view of passers-by any person who is being taken into the hospital as a patient, and also affords a secluded though somewhat restricted exercise yard for convalescent patients. We have already had one patient in the hospital, and it is gratifying to report that all of the appliances for supplying heat, water, etc., were found to be in perfect working order.

WESTPORT.

The following report of Dr. Morse, medical inspector of the Board, relates to an inspection made at Westport on account of typhoid fever: —

> On October 25 my attention was called by the board of health of the town of Westport to the presence of 7 cases of typhoid fever in the town, and it was asked that an investigation be made as to the cause of the disease. A visit was accordingly made to the family from which the cases were reported and it was found that in September, 1901, a member of the family seventeen years of age became ill with the disease while away and came home to be cared for. On July 30 of this year a brother twelve years of age was taken ill; on September 27 another brother nine years of age; on October 1 a brother seven years of age; on October 11 a brother twenty-one years of age, and on October 17 a sister eighteen years of age, were taken ill. It was apparent, from the history, that infection was transmitted directly from one member of the family to another, for all assisted at times in the care of those already ill.
>
> The well from which the water supply of the house was obtained was located at such a place that it was possible for it to be polluted, and upon examination it was found to be quite seriously contaminated. The board of health was advised to stop further use of this well.

WINCHESTER.

At the time of making our report last year we were straining every nerve to induce people to be vaccinated, hoping to keep the town free from small-pox. Free vaccination was offered and many availed themselves of the opportunity, but we regret to say that we still have many unvaccinated inhabitants.

The town has appointed a committee to report upon location and cost of a suitable building, where cases of contagious diseases may be properly treated with greatest safety to the public.

Worcester.

In comparison with 1901 there was a large reduction in the number of bathers. This was due entirely to the coolness of the season. The bath houses were opened for use June 9 and closed September 13. Eighteen thousand two hundred and sixty-eight men and boys used the men's house during the season. At the women's bath house 11,495 persons were accommodated.

In October the board adopted the following rule: —

> Pulmonary and laryngeal tuberculosis are hereby declared to be infectious and communicable diseases, dangerous to the public health. It shall be the duty of every physician who may be called to attend such cases, and of every householder in whose family these diseases exist, to report to the board of health in writing the name, age, sex, occupation and address of every person having such diseases.
>
> It shall also be the duty of the superintendent of every public or private institution or dispensary in this city to report to the board of health all cases of these diseases which may come under his observation.

The addition of this disease to the number of communicable diseases places Worcester abreast of the most progressive cities of the country, and much good is expected to result from it. At present we disinfect after the death or removal of each case. We also send a circular of instruction to the family of each patient. On December 1 reports began to be received, and to the end of the year 51 cases were reported and 28 rooms were disinfected.

The isolation hospital continues the good work of previous years. More cases were treated there than in the year preceding.

We again earnestly recommend an additional ward for mixed infections, and also for those cases of measles which an epidemic of that disease is sure to bring forth. These cases are servants in private families, employees and pupils in educational institutions, and inmates of hotels and boarding-houses. All of these are so situated that it is impossible to properly care for or isolate them, and in consequence they are a source of great anxiety and expense to the persons with whom they are connected.

We have had applications from all of these during the past three months, but were obliged to refuse because there is no provision for the care and solation of this disease at the hospital.

Record of Visits made to Cities and Towns by Medical Inspector Morse for the Purpose of Investigating 405 Cases suspected of being Small-pox during 1902.

Case No.	City or Town.	Date.	Sex.	Age.	Character.	Successfully Vaccinated.	Remarks.
1	Reading,	Jan. 2,	M.	60	Discrete,	Childhood,	Does business in Boston. Ill Dec. 28, 1901. Eruption January 1.
2	Brockton,	Jan. 3,	F.	23	-	Childhood,	Diagnosis, chicken pox. Ill three weeks ago.
3	Brockton,	Jan. 3,	F.	17 months.	-	One month ago,	Diagnosis, chicken pox. In vesicular stage.
4	Brockton,	Jan. 3,	F.	5	-	One month ago,	Diagnosis, chicken pox. In crust stage one week old.
5	Brockton,	Jan. 3,	F.	30	Discrete,	Twenty-five years ago,	Ill Dec. 28, 1901. Eruption January 1.
6	Lynn,	Jan. 3,	F.	8	-	No,	Diagnosis, chicken pox.
7	Lynn,	Jan. 3,	M.	4	-	No,	Diagnosis, chicken pox.
8	Concord,	Jan. 4,	M.	20	-	Ten months ago,	Diagnosis, chicken pox.
9	Quincy,	Jan. 4,	F.	8	Confluent,	No,	Ill Dec. 28, 1901. Eruption January 1.
10	Winchester,	Jan. 4,	M.	33	-	Five weeks ago,	Diagnosis, erythema multiforme.
11	Hopedale,	Jan. 6,	M.	35	Discrete,	Infancy,	At Boston Dec. 21, 1901. Ill January 1. Eruption January 5.
12	Quincy,	Jan. 8,	F.	7	-	Five months ago,	Diagnosis, chicken pox.
13	Marlborough,	Jan. 9,	M.	45	Discrete,	Infancy,	From Chicago Dec. 25, 1901. Ill January 5. Eruption January 7.
14–35	Northbridge,	Jan. 10,	M , F.	1–32	Confluent, discrete.	No,	Cases have existed for past three weeks unrecognized, although some of them were attended by a physician. Infection originally came from Sorelle, Canada, two months previously.
36	So. Framingham,	Jan. 11,	M.	34	Confluent,	No,	Ill January 5. Eruption January 7. Came from Boston ten days ago.
37	Brockton,	Jan. 13,	M.	31	Discrete,	Fifteen years ago,	Ill January 10. Eruption January 12. Husband of case No. 5.
38	Randolph,	Jan. 15,	F.	4	Confluent,	No,	Ill January 12. Eruption January 14. Daughter of case No. 5.
39	Marblehead,	Jan. 16,	M.	61	Discrete,	Fifty years ago,	Ill three weeks ago, unrecognized.
40	Marblehead,	Jan. 16,	M.	43	Confluent,	Forty years ago,	Infected from No. 39. Eruption in pustular stage.
41	Marblehead,	Jan. 16,	F.	34	Discrete,	Thirty years ago,	Infected from No. 39. Eruption in papular stage.

Record of Visits made to Cities and Towns by Medical Inspector Morse for the Purpose of Investigating 405 Cases suspected of being Small-pox during 1902 — Continued.

Case No.	City or Town.	Date.	Sex.	Age.	Character.	Successfully Vaccinated.	Remarks.
42	Marblehead, .	Jan. 16,	M.	10 months.	Confluent, .	No, ...	Infected from No. 39. Eruption in papular stage.
43–50	Sturbridge, . .	Jan. 17,	M., F.	1–24	Discrete, .	No, ...	First case dates back four weeks, unrecognized. Others developed since that time.
51	Stoughton, . .	Jan. 18,	F.	16	–	January 9, . . .	Vaccinal erythema over whole body.
52	Brockton, . .	Jan. 18,	M.	31	–	– –	Diagnosis, measles.
53	Mendon, . .	Jan. 19,	M.	46	Discrete, .	Childhood, . . .	Ill January 12. Eruption January 16. Eruption in vesicular stage.
54	So. Framingham,	Jan. 21,	M.	7	–	Three years ago, . .	Diagnosis, typhoid fever.
55	Randolph, . .	Jan. 22,	M.	55	Confluent, .	Forty-six years ago, .	Ill January 19. Eruption January 22. Eruption in papular stage.
56	Marlborough, .	Jan. 23,	F.	9	–	No, ...	Diagnosis, chicken pox.
57, 58	Stoughton, . .	Jan. 24,	M., F.	56, 53	Discrete, .	Forty years ago, . .	Eruption in papular stage. Exposed two weeks ago by case in house.
59	Brookline, . .	Jan. 25,	M.	37	Discrete, .	Thirty-five years ago, .	Ill January 19. Eruption January 23. Eruption in papular stage.
60	Dedham, . .	Jan. 27,	M.	19	–	Twelve years ago, . .	Diagnosis, chicken pox.
61	Canton, . .	Jan. 27,	M.	27	Confluent, .	Twenty-five years ago, .	Ill January 24. Eruption January 26. Eruption in papular stage.
62	Concord, . .	Jan. 28,	M.	49	Discrete, .	Forty-five years ago, sixteen years ago	At Boston January 11 Ill January 21. Eruption January 26. Eruption in vesicular stage.
63, 64	Newburyport, .	Jan. 31,	M.	40	Discrete, .	No, thirty-five years ago,	Eruption January 29. In vesicular stage to-day.
65	Franklin, . .	Jan. 31,	M.	29	Discrete, .	No, ...	Ill January 26. Eruption January 29. Eruption in vesicular stage.
66	Newburyport, .	Feb. 2,	M.	42	–	– –	Diagnosis, scarlet fever.
67	Brockton, . .	Feb. 3,	M.	19	Confluent, .	No, ...	Ill January 30. Eruption February 2. Eruption in papular stage.
68	Quincy, . .	Feb. 3,	M.	43	Discrete, .	Infancy, ...	Mother ill with small-pox in Boston two weeks ago. Ill January 31. Eruption appeared to-day in papular stage.
69	Bedford, . .	Feb. 3,	M.	35	–	Thirty years ago, . .	Diagnosis, erythema papulosa.
70	Lynn, . . .	Feb. 4,	M.	56	Discrete, .	Infancy, ...	Ill January 31. Eruption February 3. Eruption in papular stage.
71	Gardner, . .	Feb. 5,	F.	6	Confluent, .	No, ...	Ill January 25. Eruption January 30. Eruption in pustular stage.

72	Lynn,	Feb. 5,	M.	29	Confluent,	No,	Ill February 1. Eruption February 4. Eruption in papular stage.
73	Lynn,	Feb. 5,	M.	6	-	Two years ago,	Diagnosis, chicken pox.
74	Stoneham,	Feb. 8,	F.	23	Discrete,	No,	Visited at East Boston, returning January 29. Ill February 4. Eruption February 7. Eruption in papular stage.
75	Bedford,	Feb. 8,	M.	62	Confluent,	Infancy,	Exposed at Galloupe's Island January 23. Eruption in vesicular stage.
76	Sharon,	Feb. 10,	M.	32	Discrete,	Infancy,	Ill February 1. Eruption February 4. Eruption in pustular stage.
77, 78	Newburyport,	Feb. 11,	M., F.	14, 48	Discrete,	No, forty years ago,	Eruption in pustular stage. Exposed by case No. 63.
79	Everett,	Feb. 11,	F.	26	Discrete,	No,	Ill February 5. Eruption February 8. Eruption in pustular stage.
80	Salisbury,	Feb. 13,	M.	42	Discrete,	Childhood,	Eruption in papular state. Exposed by case No. 63.
81	Georgetown,	Feb. 14,	M.	19	-	Childhood,	Diagnosis, measles.
82	Marshfield,	Feb. 15,	F.	18	Confluent,	No,	At Boston two weeks ago and exposed there. Ill February 10. Eruption February 11. Eruption in pustular stage.
83	Marshfield,	Feb. 15,	M.	62	Discrete,	Childhood,	At Boston two weeks ago and exposed there. Ill February 10. Eruption February 11. Eruption in pustular stage.
84	Barre,	Feb. 17,	M.	47	Discrete,	No,	Ill February 10. Eruption February 11. Eruption in pustular stage. Came from Canada, January 29, where small-pox was prevalent.
85	Foxborough,	Feb. 18,	M.	34	-	-	Diagnosis, influenza.
86	Royalston,	Feb. 19,	M.	28	Confluent,	No,	Ill February 11. Eruption February 13. Eruption in pustular stage. Infected by mild case coming from North Oxford.
87	Royalston,	Feb. 19,	M.	30	Discrete,	Infancy,	Ill February 12. Eruption February 14. Eruption in pustular stage. Infected by mild case coming from North Oxford.
88	Holliston,	Feb. 20,	M.	53	Discrete,	Infancy,	Ill February 15. Eruption February 18. Eruption in vesicular stage.
89	East Douglas,	Feb. 21,	M.	24	Discrete,	Infancy,	Ill February 13. Eruption February 17. Eruption in pustular stage. Exposed at logging-camp in Uxbridge.
90	Sherborn,	Feb. 21,	F.	29	-	One month ago,	Diagnosis, measles.
91	Malden,	Feb. 22,	M.	50	Discrete,	Infancy,	Ill February 18. Eruption February 21. Eruption in papular stage.
92	Braintree,	Feb. 24,	F.	1	-	No,	Diagnosis, chicken pox.
93	Braintree,	Feb. 24,	F.	48	Confluent,	No,	Ill February 20. Eruption February 23. Eruption in papular stage. Contracted February 12 at church.
94	Dover,	Feb. 24,	M.	20	Confluent,	No,	Ill February 17. Eruption February 20. Eruption in vesicular stage.
95	Maynard,	Feb. 27,	M.	22	-	February 17,	Diagnosis, vaccination urticaria.
96	Watertown,	Feb. 28,	M.	49	Discrete,	Forty years ago,	Ill February 22. Eruption February 26. Eruption in vesicular stage.

Record of Visits made to Cities and Towns by Medical Inspector Morse for the Purpose of Investigating 405 Cases suspected of being Small-pox during 1902 — Continued.

Case No.	City or Town.	Date.	Sex.	Age.	Character.	Successfully Vaccinated.	Remarks.
97	Wareham, . .	Feb. 28,	M.	30	Discrete, .	Infancy, ...	Ill February 24. Eruption February 27. Eruption in papular stage.
98	Maynard, . .	Mar. 1,	M.	30	Discrete, .	No, ...	Ill February 25. Eruption February 27. Eruption in vesicular stage. Exposed to disease two weeks ago.
99	Hingham, . .	Mar. 1,	M.	53	Discrete, .	No, ...	Ill February 24. Eruption February 27. Eruption in vesicular stage. Had small-pox in 1849.
100	Haverhill, . .	Mar. 1,	M.	29	-	No, ...	Diagnosis, measles.
101	Waltham, . .	Mar. 2,	M.	37	-	Six months ago, . .	Diagnosis, influenza.
103	Brockton, . .	Mar. 3,	M.	27	-	Twenty years ago, .	Diagnosis, chicken pox.
104	Lawrence, . .	Mar. 3,	M.	43	Discrete, .	Infancy, ...	Ill Feb. 10. Disease not recognized.
105, 106	Lawrence, . .	Mar. 3,	F.	77, 23	Confluent, .	No, ...	Ill February 26. Eruption March 1. Eruption in vesicular stage. Disease contracted from case No. 104.
107	West Acton, .	Mar. 4,	M.	32	Discrete, .	Twenty-five years ago, .	Ill one month ago. Unrecognized.
108, 109	West Acton, .	Mar. 4,	M., F.	5, 27	Discrete, .	No, infancy, . . .	Ill two weeks ago. Eruption in crust stage.
110	Ipswich, . .	Mar. 6,	M.	23	Confluent, .	No, ...	Ill March 2. Eruption March 4. Eruption in vesicular stage.
111	Whitinsville, .	Mar. 6,	F.	11	-	One year ago, . .	Diagnosis, measles.
112	Ipswich, . .	Mar. 8,	M.	26	-	No, ...	Diagnosis, measles.
113	Waltham, . .	Mar. 9,	M.	50	-	Two weeks, . . .	Diagnosis, herpes.
114	Newburyport, .	Mar. 10,	M.	50	Discrete, .	Infancy, ...	Ill March 6. Eruption March 7. Eruption in vesicular stage.
115	Newburyport, .	Mar. 10,	M.	60	Discrete, .	Infancy, ...	Ill March 6. Eruption March 7. Eruption in vesicular stage.
116	Webster, . .	Mar. 11,	M.	38	Discrete, .	No, ...	Ill March 4. Eruption March 6. Eruption in pustular stage. Came from Canada one week ago.
117	Fiskdale, . .	Mar. 11,	F.	7	-	One year ago, . .	Diagnosis, chicken pox and scarlet fever.
118	Fiskdale, . .	Mar. 11,	F.	9	-	Three years ago, . .	Diagnosis, scarlet fever.
119	Fiskdale, . .	Mar. 11,	M.	13	-	Four years ago, . .	Diagnosis, chicken pox.
120	Fiskdale, . .	Mar. 11,	M.	3	-	Ten months ago, . .	Diagnosis, chicken pox.

121	Fiskdale,	Mar. 11,	M.	42	-	Two months ago,	Diagnosis, erythema multiforme.
122-166	Gilbertville,	Mar. 12,	M., F.	7 months-44	Confluent, discrete.	No,	Disease had been present since November, 1901, unrecognized, and spread without restriction. One hundred and seventy cases estimated to have occurred.
167-169	Ware,	Mar. 12,	M., F.	5-32	Discrete,	No,	Ill during past three weeks. Unrecognized.
170	Lynnfield,	Mar. 13,	M.	22	-	Six months ago,	No disease present.
171	Fitchburg,	Mar. 14,	M.	30	-	One year ago,	Diagnosis, chicken pox.
172	Maynard,	Mar. 14,	M.	2	-	No,	Diagnosis, chicken pox.
173	West Warren,	Mar. 15,	M.	4 months.	-	No,	Diagnosis, chicken pox.
174	Walpole,	Mar. 17,	M.	1	-	Two months ago,	Diagnosis, chicken pox.
175	Malden,	Mar. 18,	M.	29	Discrete,	Infancy,	Ill March 14. Eruption March 17. Eruption in papular stage.
176	Reading,	Mar. 18,	F.	5	-	No,	Diagnosis, chicken pox.
177	Lawrence,	Mar. 18,	M.	27	Discrete,	Infancy,	Ill March 10. Eruption March 14. Eruption in pustular stage.
178	Lawrence,	Mar. 18,	M.	27	Discrete,	Infancy,	Ill March 10. Eruption March 12. Eruption in crust stage.
179	Winchester,	Mar. 18,	F.	40	Discrete,	Infancy,	Ill March 13. Eruption March 16. Eruption in papular stage.
180-184	Gardner,	Mar. 20,	M., F.	17-52	Discrete,	No,	Cases date over period of past six weeks. Unrecognized. Infected by case from Northbridge in latter part of January.
185-189	Fitchburg,	Mar. 20,	M., F.	1-34	Discrete,	No,	Cases date over period of past three weeks. Unrecognized. Infected by case No. 181 from Gardner visiting here two days while ill.
190	Malden,	Mar. 21,	F.	18	Discrete,	No,	Ill March 15. Eruption March 17. Eruption in vesicular stage.
191	Dedham,	Mar. 21,	F.	28	-	Eight years ago,	Diagnosis, measles.
192	Methuen,	Mar. 22,	M.	21	-	No,	Diagnosis, chicken pox.
193	Newburyport,	Mar. 26,	F.	4 months.	-	No,	Diagnosis, chicken pox.
194	Ipswich,	Mar. 26,	M.	44	Discrete,	Infancy,	Ill March 19. Eruption March 23. Eruption in pustular stage. Exposed by case No. 110. Five others in family vaccinated after exposure, and none ill.
195	Weston,	Mar. 27,	M.	62	Discrete,	Infancy,	Ill March 21. Eruption March 24. Eruption in vesicular stage.
196	North Brookfield,	Mar. 28,	M.	33	Confluent,	Infancy,	Ill March 20. Eruption March 23. Eruption in pustular stage. Exposed at Gilbertville, March 6, by unrecognized case.
197	Stoneham,	Mar. 31,	M.	45	Discrete,	Thirty years ago,	Ill March 26. Eruption March 30. Eruption in papular stage. Had small-pox in 1872.

Record of Visits made to Cities and Towns by Medical Inspector Morse for the Purpose of Investigating 405 Cases suspected of being Small-pox during 1902 — Continued.

Case No.	City or Town.	Date.	Sex.	Age.	Character.	Successfully Vaccinated.	Remarks.
198	Norwell,	Mar. 31,	M.	20	-	No,	Diagnosis, chicken pox.
199	Southbridge,	April 2,	F.	23	Discrete,	No,	Ill March 24. Eruption March 28. Eruption in pustular stage.
200	Southbridge,	April 2,	F.	2	Discrete,	No,	Ill March 24. Eruption March 28. Eruption in pustular stage.
201	Brockton,	April 3,	M.	61	Confluent,	Fifty-two years ago,	Ill March 28. Eruption April 1. Eruption in papular stage.
202	Brockton,	April 4,	M.	38	Confluent,	Infancy,	Ill March 28. Eruption April 3. Eruption in papular stage.
203	Needham,	April 6,	F.	19	-	Infancy,	Diagnosis, dermititis herpetiforme.
204	Cambridge,	April 6,	F.	46	Confluent,	Infancy,	Ill April 3. Eruption April 5 Eruption in papular stage.
205	Salem,	April 7,	M.	15	Discrete,	No,	Ill February 20, unrecognized, and other cases developed traced to him.
206	Brockton,	April 7,	F.	42	-	Five times,	Diagnosis, erythema multiforme.
207	Milton,	April 7,	M.	41	Discrete,	Infancy,	Ill April 3. Eruption April 5. Eruption in vesicular stage.
208	Spencer,	April 8,	M.	43	Discrete,	Infancy,	Ill March 30. Eruption April 1. Eruption in pustular stage. Contracted at Brockton, where patient worked.
209	North Brookfield,	April 10,	F.	1	Discrete,	No,	Ill April 3. Eruption April 6. Eruption in vesicular stage. Contracted from case No. 196. Nine others in family, all vaccinated and not ill.
210	Brockton,	April 11,	F.	34	Discrete,	Infancy,	Ill April 5. Eruption April 7. Eruption in pustular stage.
211	Brockton,	April 11,	M.	17	-	Thirteen years ago,	No disease present.
212	Belmont,	April 13,	M.	25	-	Ten years ago,	Diagnosis, chicken pox.
213	Hopedale,	April 14,	M.	25	-	Five months ago,	Diagnosis, chicken pox.
214	Holden,	April 14,	M.	14	-	Five years ago,	Diagnosis, measles.
215	Athol,	April 15,	M.	54	Discrete,	Infancy,	Ill March 27. Eruption March 29. Few discs present on palms of hands.
216	Athol,	April 15,	M.	38	Discrete,	March 29,	Ill April 10. Eruption April 12. Eruption in vesicular stage.
217	Malden,	April 16,	F.	20	Discrete,	Ten years ago,	Ill April 13. Eruption April 15. Eruption in papular stage.
218	Randolph,	April 17,	M.	40	Confluent,	No,	Ill April 8. Eruption April 10. Eruption in pustular stage.

219-221	Watertown,	April 18,	M., F.	2-35	Confluent, discrete.	Ten years ago, no,	Ill April 13. Eruption April 16. Eruption in papular stage.
222, 223	Athol,	April 21,	M.	39, 42	Confluent,	No,	Ill April 18. Eruption April 20. Eruption in papular stage.
224	Waltham,	April 23,	F.	23	Confluent,	No,	Ill April 18. Eruption April 22. Eruption in papular stage. Patient sent to hospital with diagnosis of typhoid fever.
225	Fitchburg,	April 23,	F.	26	Discrete,	No,	Ill April 18. Eruption April 20. Eruption in vesicular stage.
226	Athol,	April 27,	M.	27	Confluent,	No,	Ill April 23. Eruption April 26. Eruption in papular stage.
227	Medford,	April 28,	M.	32	-	Nine years ago,	Diagnosis, measles.
228	Orange,	April 28,	M.	62	Discrete,	Infancy,	Ill April 21. Eruption April 24. Eruption in pustular stage.
229	Brockton,	April 30,	F.	3	Confluent,	No,	Ill April 18. Eruption April 21. Eruption in crust stage. Disease unrecognized by attending physician.
230	Arlington,	May 2,	F.	19	Discrete,	April 16,	Ill April 29. Eruption April 30. Eruption in papular stage.
231	Watertown,	May 5,	M.	45	Discrete,	Twenty years ago,	Ill April 29. Eruption May 4. Eruption in papular stage.
232	Blackstone,	May 6,	M.	9	Confluent,	No,	Ill April 30. Eruption May 1. Eruption in pustular stage.
233	Brockton,	May 6,	M.	22	-	Infancy,	Diagnosis, chicken pox.
234	Windsor,	May 9,	M.	28	Discrete,	No,	Ill May 2. Eruption May 5. Eruption in pustular stage.
235	Southbridge,	May 12,	F.	22	Discrete,	No,	Ill May 2. Eruption May 5. Eruption in pustular stage.
236-240	Southbridge,	May 12,	M., F.	1-32	Discrete,	Twenty years ago, no,	Disease dates back for two weeks. Unrecognized.
241	Malden,	May 13,	F.	6	-	Eight months ago,	Diagnosis, chicken pox.
242	Amesbury,	May 13,	F.	42	Confluent,	No,	Exposed to small-pox in Boston for two hours April 28. Ill May 7 Eruption May 8. Eruption in vesicular stage.
243	Malden,	May 14,	M.	18	Discrete,	No,	Ill May 11. Eruption May 13. Eruption in papular stage.
244	Brockton,	May 15,	F.	31	Discrete,	Infancy,	Ill May 10. Eruption May 14. Eruption in papular stage. Aunt of case No. 229.
245	Beverly,	May 16,	M.	42	Discrete,	Infancy,	Ill May 8. Eruption May 10. Eruption in pustular stage.
246	Malden,	May 17,	M.	22	Confluent,	No,	Ill May 13. Eruption May 16. Eruption in papular stage.
247, 248	Malden,	May 17,	M., F.	3, 43	Confluent, discrete.	No, infancy,	Ill May 12. Eruption May 15. Eruption in papular stage.
249	Malden,	May 19,	F.	23	Discrete,	Infancy,	Ill May 8. Eruption May 12. Eruption in crust stage. Disease unrecognized.
250	Lawrence,	May 19,	F.	32	Discrete,	Infancy,	Ill May 15. Eruption May 17. Eruption in vesicular stage.
251	Brockton,	May 19,	F.	3	-	No,	Diagnosis, chicken pox.

Record of Visits made to Cities and Towns by Medical Inspector Morse for the Purpose of Investigating 405 Cases suspected of being Small-pox during 1902 — Continued.

Case No.	City or Town.	Date.	Sex.	Age.	Character.	Successfully Vaccinated.	Remarks.
252	Malden,	May 21,	F.	24	Discrete,	Infancy,	Ill May 17. Eruption May 20. Eruption in papular stage.
253	Lawrence,	May 23,	F.	19	Confluent,	No,	Ill May 19. Eruption May 22. Eruption in papular stage.
254	Lawrence,	May 23,	F.	7	-	No,	Diagnosis, chicken pox.
255	Malden,	May 24,	M.	59	Discrete,	Forty years ago,	Ill May 22. Eruption to-day in papular stage. Exposed to cases Nos. 247 and 248.
256	Malden,	May 24,	M.	34	Discrete,	Infancy,	Ill May 20. Eruption May 23. Eruption in papular stage.
257, 258	Brockton,	May 26,	M., F.	8-5	-	Three years ago, six months ago.	Diagnosis, chicken pox.
259-265	Andover,	May 26,	M., F.	1-42	Confluent, discrete.	Infancy, no,	Disease has existed unrecognized since April 17.
266	Royalston,	May 31,	M.	22	-	Infancy,	Diagnosis, measles.
267	Sheffield,	June 2,	M.	24	Confluent,	No,	Ill May 26. Eruption May 27. Eruption in pustular stage. Infected from one of Hi Henry's Minstrels who was ill, unrecognized, with small pox at Pittsfield, May 12.
268	Pittsfield,	June 2,	M.	27	Discrete,	May 17,	Ill May 23. Eruption May 25. Eruption in pustular stage. Infected from one of Hi Henry's Minstrels who was ill, unrecognized, with small-pox at Pittsfield, May 12.
269	Pittsfield,	June 2,	M.	23	Discrete,	No,	Ill May 26. Eruption May 29. Eruption in pustular stage. Infected from one of Hi Henry's Minstrels who was ill, unrecognized, with small-pox at Pittsfield, May 12.
270	Malden,	June 4,	F.	8	-	No,	Diagnosis, chicken pox.
271	Malden,	June 15,	M.	22	-	One year ago,	Diagnosis, typhoid fever.
272	Malden,	June 15,	F.	26	Confluent,	No,	Ill June 10. Eruption June 13. Eruption in papular stage.
273	Swampscott,	June 18,	M.	19	Confluent,	No,	Ill June 14. Eruption June 17. Eruption in papular stage.
274	Malden,	June 18,	M.	46	Discrete,	Infancy,	Ill June 10. Eruption June 13. Eruption in pustular stage.
275	Milton,	June 20,	F.	6	-	One year ago,	Diagnosis, chicken pox.
276	Attleborough,	June 21,	F.	28	Discrete,	No,	Ill June 12. Eruption June 17. Eruption in pustular stage.
277	Watertown,	June 22,	F.	5	-	No,	Diagnosis, scarlet fever.
278	Watertown,	June 22,	F.	5	-	One year ago,	Diagnosis, chicken pox.

279	Quincy,	June 23,	F.	20	-	Infancy,	Diagnosis, dermititis medicamentosa.
280-284	Marblehead,	June 28,	M., F.	30-65	Discrete,	Infancy,	Disease has existed, unrecognized, since June 7.
285	Watertown,	July 2,	F.	24	Discrete,	Infancy,	Exposed to small-pox June 17 to 20. Ill June 28. Eruption July 1. Eruption in papular stage.
286	Arlington,	July 8,	M.	32	-	Infancy,	Diagnosis, measles.
287	Cliftondale,	July 9,	F.	40	Confluent,	No,	Ill July 4. Eruption July 8. Eruption in papular stage.
288	Medford,	July 12,	M.	28	Discrete,	Infancy,	Ill July 8. Eruption July 11. Eruption in papular stage.
289	Winchester,	July 15,	M.	16	Confluent,	No,	Ill July 10. Eruption July 13. Eruption in papular stage.
290	Brookfield,	July 17,	F.	9	-	No,	Diagnosis, chicken pox.
291	Arlington,	July 21,	F.	38	Discrete,	Infancy,	Ill July 17. Eruption July 19. Eruption in papular stage.
292	Melrose,	July 21,	M.	26	-	One year ago,	Diagnosis, measles.
293	Medford,	July 27,	M.	5	-	No,	Ill July 23. Eruption July 26. Eruption in papular stage.
294	Milton,	July 31,	M.	6	-	One year ago,	Diagnosis, chicken pox.
295	Medford,	July 31,	F.	45	Hemorrhagic,	Infancy,	Ill July 24. Eruption July 30. Eruption in hemorrhagic stage.
296	Arlington,	Aug. 1,	F.	27	Discrete,	No,	Ill July 29. Eruption August 1. Eruption in papular stage.
297	Arlington,	Aug. 1,	M.	28	Discrete,	Infancy,	Ill one month ago. Unrecognized.
298	Westfield,	Aug. 5,	M.	25	Discrete,	No,	Ill July 30. Eruption August 2. Eruption in pustular stage.
299	Arlington,	Aug. 8,	M.	1	Discrete,	August 1,	Eruption to-day in papular stage.
300	Melrose,	Aug. 11,	M.	23	-	-	Diagnosis, typhoid fever.
301	Fitchburg,	Aug. 12,	F.	14	Discrete,	No,	Ill August 2. Eruption August 4. Eruption in pustular stage.
302, 303	Lawrence,	Aug. 20,	M., F.	2, 30	Confluent,	No, infancy,	Ill August 16. Eruption August 19. Eruption in papular stage.
304	Brockton,	Aug. 27,	M.	1	Discrete,	August 17,	Ill August 24. Eruption to-day in papular stage.
305, 306	Brockton,	Aug. 27,	M., F.	27, 28	Discrete,	Infancy,	Ill August 23. Eruption to-day in papular stage.
307	Abington,	Aug. 29,	M.	49	Discrete,	Infancy,	Ill August 24. Eruption August 26. Eruption in vesicular stage.
308-311	Rockport,	Sept. 11,	M , F.	2-40	Discrete,	No, infancy,	Disease present since August 10. Unrecognized.
312-314	Rockport,	Sept. 11,	M., F.	22-77	Discrete,	Infancy,	Disease present since June 17. Unrecognized.

Record of Visits made to Cities and Towns by Medical Inspector Morse for the Purpose of Investigating 405 Cases suspected of being Small-pox during 1902 — Continued.

Case No.	City or Town.	Date.	Sex.	Age.	Character.	Successfully Vaccinated.	Remarks.
315	Salem,	Sept. 23,	F.	28	Discrete,	No,	Ill September 16. Eruption September 18. Eruption in vesicular stage.
316	Leominster,	Sept. 28,	M.	21	Discrete,	No,	Ill September 23. Eruption September 25. Eruption in vesicular stage.
317, 318	Everett,	Sept. 30,	M.	2	Confluent,	No,	Disease present since August 17. Unrecognized.
319, 320	Everett,	Sept. 30,	F.	1, 40	Confluent, discrete.	No, infancy,	Disease present since September 14. Unrecognized.
321	Stoughton,	Oct. 3,	M.	59	Discrete,	Infancy,	Ill September 28. Eruption September 30. Eruption in papular stage.
322	Saugus,	Oct. 6,	F.	11	-	No,	Diagnosis, chicken pox.
323-326	Salisbury,	Oct. 16,	M.	2 months-33	Discrete,	No,	Disease present for past five weeks. Unrecognized.
327	Medford,	Oct. 23,	M.	30	Discrete,	Infancy,	Ill October 18. Eruption October 20. Eruption in papular stage.
328	Marlborough,	Oct. 23,	M.	23	Discrete,	No,	Ill October 20. Eruption October 22. Eruption in papular stage.
329	Malden,	Oct. 25,	M.	30	Discrete,	Infancy,	Ill October 20. Eruption October 24. Eruption in papular stage.
330	Everett,	Oct. 25,	F.	8	-	Three years ago,	Diagnosis, chicken pox.
331	Medford,	Oct. 27,	M.	38	Discrete,	No,	Ill October 18. Eruption October 20. Eruption in crust stage.
332-336	Dudley,	Oct. 27,	M , F.	1-62	Discrete,	No,	Disease present for past four weeks. Unrecognized.
337-346	Webster,	Oct. 27,	M., F.	3-50	Discrete,	No,	Disease present for past three weeks. Unrecognized.
347	Marlborough,	Oct. 28,	F.	28	Discrete,	Infancy,	Ill October 19. Eruption October 23. Eruption in pustular stage.
348, 349	Marlborough,	Oct. 29,	M.	25, 31	Discrete,	Infancy, no,	Ill October 21. Eruption October 24. Eruption in pustular stage.
350	Lynn,	Nov. 3,	F.	30	-	Eleven years ago,	Diagnosis, chicken pox.
351	Malden,	Nov. 3,	F.	10	-	Five years ago,	Diagnosis, impetigo.
352	Marlborough,	Nov. 6,	F.	31	Discrete,	No,	Ill November 3. Eruption November 5. Eruption in papular stage.
353	Marlborough,	Nov. 11,	M.	12	-	One month ago,	Diagnosis scabies.
354, 355	Marlborough,	Nov. 11,	M., F.	2, 4	Discrete,	No,	Children of case No. 349. Eruption in vesicular stage.

356	Marlborough,	Nov. 12,	F.	23	Discrete,	No,	Ill November 8. Eruption November 11. Eruption in papular stage.
357	Brookline,	Nov. 12,	M.	19	Confluent,	No,	Ill November 9. Eruption November 11. Eruption in papular stage.
358	Medford,	Nov. 13,	F.	15 months,	-	No,	Diagnosis, chicken pox.
359	Hopedale,	Nov. 14,	M.	26	Confluent,	No,	Ill November 11. Eruption November 13. Eruption in papular stage.
360	Natick,	Nov. 15,	M.	13	-	Infancy,	Diagnosis, erythema multiforme.
361	Malden,	Nov. 16,	M.	27	-	One year ago,	Diagnosis, chicken pox.
362	Cliftondale,	Nov. 21,	M.	45	Discrete,	Infancy,	Ill November 16. Eruption November 19. Eruption in papular stage.
363	Northborough,	Nov. 21,	F.	6	-	No,	Diagnosis, urticaria.
364	Marlborough,	Nov. 24,	M.	26	Discrete,	No,	Ill November 17. Eruption November 21. Eruption in vesicular stage.
365	Lawrence,	Nov. 25,	M.	37	Discrete,	No,	Ill November 17. Eruption November 20. Eruption in pustular stage.
366	Quincy,	Nov. 26,	F.	51	Discrete,	Infancy,	Ill November 23. Eruption November 26. Eruption in papular stage.
367	Maynard,	Nov. 28,	M.	22	Discrete,	No,	Ill November 21. Eruption November 25. Eruption in vesicular stage.
368	Brookline,	Nov. 28,	F.	28	Confluent,	No,	Ill November 24. Eruption November 27. Eruption in papular stage.
369	Medford,	Nov. 28,	M.	33	-	One year ago,	Diagnosis, urticaria.
370	Marlborough,	Nov. 29,	M.	41	Confluent,	No,	Ill November 22. Eruption November 26. Eruption in pustular stage.
371	Northbridge,	Dec. 1,	M.	8 months,	-	No,	Diagnosis, chicken pox.
372	Saugus,	Dec. 1,	F.	19	Discrete,	Infancy,	Ill November 20. Eruption November 21. Eruption in crust stage.
373	Lynn,	Dec. 2,	F.	22	-	Infancy,	Diagnosis, impetigo.
374	Lawrence,	Dec. 4,	F.	54	Confluent,	Infancy,	Ill November 28. Eruption December 1. Eruption in vesicular stage.
375	Lawrence,	Dec. 4,	M.	30	Discrete,	Infancy,	Disease present for three weeks. Unrecognized.
376	Newburyport,	Dec. 6,	M.	30	-	Eight years ago,	Diagnosis, syphilis.
377	Salem,	Dec. 10,	F.	38	-	Infancy,	Diagnosis, chicken pox.
378	Watertown,	Dec. 11,	M.	43	Discrete,	Thirty years ago,	Ill December 6. Eruption December 10. Eruption in papular stage.
379	Lawrence,	Dec. 11,	M.	42	-	Infancy,	Diagnosis, syphilis.
380	Lawrence,	Dec. 11,	F.	44	Discrete,	Infancy,	Ill December 6. Eruption December 9. Eruption in vesicular stage.

Record of Visits made to Cities and Towns by Medical Inspector Morse for the Purpose of Investigating 405 Cases suspected of being Small-pox during 1902 — Concluded.

Case No.	City or Town.	Date.	Sex.	Age.	Character.	Successfully Vaccinated.	Remarks.
381	Malden,	Dec. 12,	M.	46	Discrete,	Infancy,	Ill December 5. Eruption December 10. Eruption in vesicular stage.
382	Natick,	Dec. 16,	M.	38	Discrete,	Infancy,	Ill December 8. Eruption December 9. Eruption in pustular stage.
383-389	Cochituate,	Dec. 16,	M., F.	18-40	Discrete,	No,	Disease has existed, unrecognized, for past five weeks.
390-395	Cochituate,	Dec. 17,	M., F.	20-68	Discrete,	No,	Disease has existed, unrecognized, for past ten days.
396	Saxonville,	Dec. 17,	M.	23	Confluent,	No,	Ill December 11. Eruption December 13. Eruption in vesicular stage.
397	Maynard,	Dec. 19,	M.	3	Discrete,	No,	Ill December 12. Eruption December 14. Eruption in pustular stage.
398	Whitman,	Dec. 27,	F.	35	Confluent,	No,	Ill December 20. Eruption December 24. Eruption in vesicular stage.
399	Lawrence,	Dec. 27,	M.	6	-	Four months ago,	Diagnosis, chicken pox.
400	Lynn,	Dec. 28,	F.	42	Confluent,	No,	Ill December 23. Eruption December 27. Eruption in papular stage.
401, 402	Lynn,	Dec. 28,	F.	27, 50	Discrete,	No, thirty years ago,	Ill December 25. Eruption to-day in papular stage.
403	Lynn,	Dec. 28,	M.	33	Confluent,	Infancy,	Ill December 14. Eruption December 26. Eruption in papular stage.
404	Lynn,	Dec. 30,	M.	33	Discrete,	Infancy,	Ill December 10. Unrecognized, and infected Nos. 400-403.
405	Marlborough,	Dec. 30,	M.	38	Discrete,	Infancy,	Ill December 21. Eruption December 24. Eruption in pustular stage.

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